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The effect of arsenic as used in the control of grasshoppers upon birds

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NOTE TO USERS

THE EFFECT OF ARSENIC AS USED IN THE CONTROL OF GRASSHOPPERS UPON BIRDS

BY

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TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd)

TABLE OF CONTENTS (Cont'd)

I. INTRODUCTION

Grasshoppers have always been one of the most destructive insect pests known to civilized man. As far back as we have any records, we find them injuring man's products. In Biblical times, swarms of locusts destroyed every green thing in certain areas. Within the memory of many now living, the early settlers of that area lying between the Mississippi River and the Rocky Mountains saw great swarms of locusts settle and completely destroy all crops above the ground. During the past summer there were areas where grasshoppers destroyed immense amounts of crops.

Although records of early attempts to combat them are very incomplete, it is probable that from the beginning of history man has waged battle with these insects and, until the coming of modern methods and conditions, has for the most part fought a losing fight.

Of the modern methods of combating these pests after they have become numerous in the fields there is one that stands out above all others. This consists of poisoning them by placing an arsenical in some medium upon which the grasshoppers feed and scattering it in the fields where they

are feeding.

The method was first reported on by Coquillett (9) in California in 1885. The formula consisted of bran, arsenic, sugar, and water. This mixture was placed in small piles throughout the fields where the experiment was carried on, and usually in the shade. Coquillett used this bait over some 300 acres of land and reported it very successful as it almost entirely cleaned up the infestation. He also states, "Several other parties used this poisonous mash, and so far as I was able to learn, it gave entire satisfaction in every instance".

In spite of the fact that such satisfactory results were obtained at this time, and in spite of several serious outbreaks in the meantime, the method was used comparatively little for the next several years. No doubt one of the contributing factors to the reluctance with which the control measure was taken up was the fear of poisoning domestic animals and birds as well as grasshoppers in scattering poison so promiscuously over the place.

The poison bait method received its next impetus with the announcement of Norman Criddle about 1900 that the grasshoppers could be killed by a bait similar to the one suggested by Coquillett, but in this case horse manure was substituted for the bran. Such a substitute, of course, cheapened

the bait very materially and in some localities, under certain conditions at least, it was very effective. This method also failed to become popular over the country as a whole. The same objection still held with regard to scattering poison and, in addition, the nature of the ingredients made this bait disagreeable to mix and scatter.

The poison bait method really became popular following its marvelous success in Kansas in 1913, as reported by Dean (12) and Hunter (28) in 1914. During this campaign 874 tons of poison bran mash were distributed over a number of counties in western Kansas, and resulted in so diminishing the grasshopper population of these counties that very little damage occurred after the poison was put out, whereas before grasshoppers were so numerous that they were destroying thousands of dollars worth of crops daily.

The formula used during this campaign was as follows: bran, 20 pounds; Paris green, 1 pound; oranges or lemons, 3 fruits; syrup, 2 quarts; and water, 3½ gallons. Thus it is seen that this formula differs from the one used by Coquillett in 1885 in that another form of arsenical was used, the proportions were different and an attrahent was added. Still, in its essential respects, it was the same as the first formula used.

This formula became known as the "Kansas bait" and

almost immediately became very widely used and its success when used under the proper conditions was almost unquestioned. Since that time there have been slight changes made in the formula and time of day that it is to be scattered but it, or its variations, have become standard over the entire country where grasshopper outbreaks occur, and it is generally considered among entomologists to be the best control of grasshoppers known after they have become numerous in the fields.

In looking back over this brief outline of the history of poison bran mash as a control for grasshoppers, it is seen that there was a period of approximately 30 years from the time its effectiveness first became known until it became widely and generally used. In the interim, thousands of dollars worth of crops were destroyed that might have been saved had the information that was then available been used, and every year there are numerous cases where it would pay large dividends to use poison bran mash where it is not used.

It is the writer's opinion that the fear of poisoning domestic fowls and wild birds is not a major reason for so many failures to use grasshopper bait, when it should be used, but there are instances where this fear does play an important part. It has been his experience that in many communities

where it is desired to put out poison, individuals are to be found who firmly believe that such a procedure is likely to result in the death of a large percentage of the birds of the area. In practically every community where poison bran mash has been used are found individuals who cite instances where birds or other animals have been killed through its use; usually they tell of instances of which they have heard rather than those they have seen themselves, but plenty are found who claim first hand information concerning such cases. In addition to those that are told about the community, there also appear in various papers similar stories, which give additional weight to those that are told.

Two examples are given of such stories that appeared in papers receiving a large circulation in this particular community during the last summer. One appeared in the Stillwater Daily Press, Sept. 8, 1931. This was a United Press article under the heading of Winner, South Dakota, and read as follows: "Farmers in the Rosebud country have lost thousands of dollars worth of hogs and poultry because of the widespread use of poison to curtail the grasshopper plague. Hundreds of pheasants have also died after eating grasshoppers which had been killed by the poison mash."

In the Oklahoma Farmer Stockman of Aug. 15, 1931,

page 5, was printed the following letter sent in by a subscriber: "..... there is one thing it (referring to the Oklahoma Farmer Stockman), as well as other papers, the Experiment Station and County Agents, advocates that is doing vastly more harm than good. I refer to the use of insect poison, especially grasshopper dope. The wholesale scattering of this dope in some parts of this state has almost annihilated the birds, the farmer's best friends. Mother birds are killed and the young ones left in the nest to starve. It has been a veritable slaughter of the innocent. You can drive for miles along some of our highways without seeing a bird, where there used to be hundreds. And what is accomplished by all this poisoning? The more poison you put out the more birds you kill and the more insects you have. ..... If this cruel practice of scattering poison over our farms is not stopped, it won't be long until birds will be a thing of the past in Oklahoma, and the whole state will be the loser and no one be the gainer except the few engaged in the manufacture of this devilish poison. Stop it."

The writer of the above was obviously radical in his views, but such statements have a dampening effect on grasshopper poisoning campaigns and thus far we have very little experimental evidence to indicate that such stands are not well taken. It is true that numerous observations have

been made that domestic animals and fowls were not killed when poison bran mash has been put out, but on the other hand, it is also true that dead fowls and animals have been found in vicinities where the poison has been spread. This, to one group, is just as positive proof that it does kill as the lack of dead animals is to the other that it does not.

A few years ago in Oklahoma, it became necessary to use poison bran mash in large amounts and, as usual, there were individuals who insisted that its use was dangerous to other animals, particularly birds, including quail. The fact that dead quail were found where the poison had been put out gave weight to their argument.

Another story that received considerable circulation was to the effect that the poisoned grasshoppers were either blown or washed into the streams and ponds and eaten by the fish. The fish, in turn, were caught and eaten by people and the people were thus poisoned. According to R. R. Reppert (47), Extension Entomologist of Texas, similar stories were told in 1924 in the vicinity of Brady, Texas, and they also received newspaper circulation.

According to J. W. Barber (1), District Extension Agent at Pocatello, Idaho, there was a case at Oakley, Idaho, where a number of persons became ill after eating a dinner

of chickens that had had access to large numbers of poisoned grasshoppers. The local physician diagnosed the illness as being arsenical poisoning. The general belief was that the poisoning of the persons resulted from the poison that was in the chickens' bodies after eating the grasshoppers.

These are only a few of the large number of stories that have been told in the past and are still told wherever poison mash is spread. Since the use of poison bran mash has become popular, those who have worked with it most have become convinced from their experiences that the danger of poisoning other animals when it is properly used is very slight. However, even among scientists there appears to have been considerable difference of opinion as to this point. Therefore it is not surprising that the layman should be considerably disturbed concerning this possibility.

A search of the literature on the subject reveals that though the matter has been given careful consideration and close observation since poison bran mash was first used, there has been an exceedingly small amount of experimental work carried on in an attempt to determine the amount of danger arising from the spreading of the poison. It was therefore felt that more information was needed and as a result, this present work was started to determine the effect of poison bran mash as used in the control of grasshoppers upon birds.

II. REVIEW OF LITERATURE

Coquillett (9), who introduced grasshopper bait, makes the following statements concerning its danger to other animals: "By exercising only ordinary precautions there need be no fear of endangering the lives either of man or any of the domestic animals in using this poisonous preparation. It should be mixed in a closed room to prevent the arsenic from being blown about by the wind. There is no need of touching the arsenic or the mixture with the hands, as the mixing and distributing is accomplished by means of spades, shovels, wooden paddles, etc.

"Of course this mixture should not be put out where poultry or any of the domestic animals can gain access to it. Upon the Buhach plantation were four grey hounds and several cats that were allowed to roam about the plantation where this mixture had been put out for the locusts; still at the time I left the plantation - about four weeks after the poisonous mixture had been put out - not one of them had been killed, either by eating of the mixture itself or of the locusts that had been poisoned by it.

"There were also several barnyard fowls upon this plantation, but not one of them was poisoned from having eaten

locusts that may have found their way to the poultry range after having eaten the poisonous mixture. Mr. Boynton, whose farm adjoins the Buhach plantation on the west, stated to me that many of the locusts which had eaten the poisonous mixture would fall into an irrigation ditch that flowed through his poultry yard and many of the locusts were thus carried within reach of his fowls; still he was not aware that any of the latter had died from the effect of having eaten of the poisoned locusts. In fact, I did not learn of a single instance where this mixture had caused the death of any person or of any domestic animal, although it was used very extensively in many parts of the San Joaquin Valley. Neither were the birds killed in any considerable numbers from having eaten either of the mixture itself or of the locusts that had been poisoned by it. During the four weeks following the putting out of this mixture upon about 300 acres of the Buhach plantation I found only about a half a dozen dead birds that had evidently met their death through the agency of this mixture; these consisted of 3 or 4 meadow larks, a bee bird and a field sparrow.

"Rabbits and hares, or "Jack rabbits", as they are called, were destroyed in large numbers by the mixture..... As the mixture is saturated with water before it is put among the plants infested with locusts, there is no danger of its

being blown about by the wind; and there is also very little danger of its being deposited upon the fruits by the feet of birds and insects that may have alighted upon the mixture and afterwards flown to and alighted upon the fruits. As the mixture becomes dry, its particles adhere together, forming a solid mass which could not be blown about by the wind.

"I have never seen this poisonous mixture used in grain fields, but know of no reason why it would not prove effectual in such fields. Great care should be used in using it in alfalfa fields, but if it were placed upon small pieces of boards it could doubtless be used with entire safety in such fields; but of course it would not be safe to pasture any animals in such fields even after the poison had been removed."

Thus we see that from the very beginning this phase of the problem has been carefully observed, not only from the standpoint of poisoning domestic and wild animals and birds but also man. In summing up Coquillet's discussion, it appears to be his belief that the mixture can be used safely providing the following conditions are met: (1) It shall be mixed indoors; (2) poultry and domestic animals of all kinds, excepting cats and dogs, shall not have access to the fields when the mixture is used; (3) the mixture must

be saturated to prevent the poison being blown about by the wind and must be placed in piles for the same reason; (4) if used in alfalfa or similar fields those fields must not be pastured, even after the poison has been removed. He also is of the opinion that a few, but not many, wild birds are killed from its use.

The other statements found in literature have been divided into two groups; (1) Those that minimize the danger to poultry and domestic animals; and (2) those that indicate the danger is definite. Those of the first group will be discussed first.

Washburn (55) in 1903 in replying to a question concerning the danger of Criddle mixture's poisoning turkeys and chickens, states "I do not hesitate to say then that the Criddle mixture is perfectly safe in this connection as far as full grown fowls are concerned." In this same publication, he quotes from a letter received from Dr. Fletcher of Canada who was familiar with conditions where large amounts of this bait had been used. In reply to the question, "How about turkeys and chickens eating the dead grasshoppers?" Dr. Fletcher replied that either these were not eaten or if they were, no ill effect followed because no complaint of this kind had ever been made.

Hunter and Claassen (28) in 1914 state "Chickens

eating the poisoned hoppers do not appear to be affected". In discussing the advantages of sowing the bran rather than putting it out in small piles, they state, "It eliminates all danger of poisoning fowls or stock".

Dean (12) in 1914, after supervising the distribution of 874 tons of poison bran mash in a number of counties in western Kansas, recommends that it be used at the rate of 4 pounds per acre and states, "This rate well scattered makes it impossible for birds, barnyard fowls or livestock to secure a sufficient amount of poison to kill them".

Webster (56) in 1915 tells of two applications of poison bran mash or Criddle mixture being used with the result that as high as 550 dead grasshoppers were found per square foot. In commenting on the danger of this method to other animals, he states, "Some of this work was carried on in pastures where valuable cattle were continuously grazing and in no instance did any domestic animal or bird suffer the least ill effect, as far as could be observed".

Felt (14), in 1915, in reporting on the use of the Kansas formula states, "We were unable to learn of any deleterious effects resulting from the use of this material when ordinary precautions were used".

Milliken (38), also in 1915, states, "Neither domestic animals nor birds can secure enough poisoned bait

to kill them if the bait is scattered evenly as suggested".

Merrill (37) in 1916 states, "Experimentation has shown that there is no danger to poultry from eating the bran mash if it is scattered broadcast. The writer has seen no dead birds over the ground that was treated..... Reports have come to the writer, of chickens dying from eating the grasshoppers both alive and poisoned. Such deaths were evidently due to overeating of a food to which the fowls were not accustomed." No reasons for the latter statement were given.

Milliken (39) in 1916 states that in 1913 - 1,000 tons of poison bran mash were used in Kansas and "not even wild birds were killed". "All cases of poisoning were due to carelessness." This bait has been used over much of the United States and Canada and "in every case emphasis has been placed on the absence of poisoning among domestic animals and birds".

Cooley, Parker, and Seamans (7) in 1918, in reporting on the results of a large grasshopper campaign carried on in Montana, state, "Hogs, horses and poultry were killed by eating the poisoned bran mash during the grasshopper campaign of 1917, but such accidents were in every case due to carelessness for which there was no excuse".

Dean, Kelly, and Ford (13) in 1919 point out that

although 35,500 pounds of white arsenic were used in 8 counties of western Kansas, "Very few cases of poultry or stock poisoning were reported, and without exception, all such cases were due to carelessness on the part of the farmer".

Watson (57) in 1919, in speaking of Kansas bait says "If sown in small flakes over the field, there will be no likelihood of chickens or other domestic animals picking it up, nor will wild birds be endangered. Ordinarily there will be no danger to chickens or other fowls eating the dead grasshoppers, as the fowls will not get enough arsenic in this way to harm them."

Corkins (11), in 1923, is still more positive in his statements. In his bulletin, which discussed grasshopper control, under the heading of "Stock poisoning" he states "If the bran mash is mixed and spread according to directions, there is no danger of poisoning either stock or fowls. In the writer's experience in large campaigns in 3 different states he has not known the loss of any animals except from carelessness around the mixing vats. The only caution is to keep all mixing utensils away from children and domestic animals."

Cooley, Parker, and Strand (8) in 1923 after warning that fatal results to stock are likely to occur if great care

is not taken where the poison is mixed and with the containers used, state "Poisoning stock has not occurred from their picking up poisoned bran which has been broadcast in the proper manner, mash which has been prepared from coarse wheat bran and scattered at the rate recommended in this circular (5 to 15 pounds per acre) is not dangerous to cattle, horses, poultry or birds. In fact, the mixture can be applied to pastures where stock is feeding without any risk of serious results."

Granovsky (22) in 1926 in reporting on a campaign carried on in Wisconsin where sawdust was substituted for bran and 1,000 acres covered during the campaign, states, "The poison bait was scattered among sheep, cattle, and horses under all conditions on farms, without a single case of animal poisoning".

Van Zyl (54) in 1929, after carrying on some experimental work discussed later in this paper, concluded that under South African conditions, where his work was done, little if any danger existed from fowls' feeding upon poisoned locusts.

It is evident from these statements that the above named workers did not consider the use of poison bran mash involved any danger as long as it was properly used.

The other side of the question is presented by the

following workers:

Bruner (4) in 1893 had been called to the Grand Junction district of Colorado to investigate a grasshopper outbreak. Here poison bran mash had been used and the following is taken from the report he made after viewing the situation; "Some bran and arsenic was used, but so carelessly in many instances that not only were the domestic fowls and an occasional larger animal, but also nearly all of the native birds of the region, destroyed. Only one good feature of the use of this remedy was the destruction of many rabbits."

Lugger (35), in 1897, in discussing various means that might be used in combating grasshoppers states, "Poisoning locusts in garden and fields from which chickens and cattle may be kept away, may also be resorted to with good results using bran mash as poisoned bait".

Pettit (43) in 1905 says, "Poison bran can be used only in situations where stock and poultry are excluded. Neither should it be used where partridge and quail are likely to feed."

Hunter (27) in 1905 states, "While livestock, and especially chickens, are very liable to be poisoned if they are allowed to have access to the grasshopper poison, there seems to be very little danger of poisoning beneficial wild

birds, for careful watch was kept while the poison was out for any that might have got hold of either the poison or the dead grasshoppers, and not a single dead bird was found."

Garcia (19), in 1908, in discussing the control of grasshoppers in New Mexico, states, "Care should be taken to see that chickens or other domestic fowls or animals do not eat the poison bran".

In considering the above statements, it should be remembered that up to this time it was still frequently or entirely recommended that the poison mash be put out in balls or small piles. This, of course, is a different situation from the now universally recommended practice of scattering it broadcast. Garman (20) in 1909 discussed briefly the control of grasshoppers in corn in Kentucky. Then, probably referring to the more thinly populated portions of the country, he states, "In grasshopper countries, good results are obtained by making a bait of poison bran and molasses and scattering it about the fields; but such baits are not safe in thickly settled countries where poultry or other animals are likely to eat them".

Washburn (56) in 1911, in discussing the use of Criddle mixture, appears to be of the opinion that the danger of poisoning is limited to young fowls. His statement is as follows: "One might think that turkeys and other fowls, in

picking over such material for bits of undigested grain, might be poisoned. This, in our experience, does not seem to be the case. It would probably be dangerous if used in the proximity of small chickens."

Kaupp (32), a veterinarian, in 1912 in his bulletin discussing diseases of poultry, states, "We have had cases brought to our attention in which birds became poisoned by eating poisoned grasshoppers. In these cases the grasshoppers were given arsenic in bran. The birds devouring large numbers of grasshoppers became ill and many died." The statement is followed by a description of the symptoms and autopsy, which closely correspond with those of arsenical poisoning.

Shoesmith (49) in 1913, in discussing the control of grasshoppers in alfalfa, says, "Poisoned bran can be used only in situations where stock and poultry are excluded. Neither should it be used where partridge or quail are likely to feed."

Jones (29) in 1917, in discussing poison bran mash as a control of grasshoppers, states, "This mixture should be used with care where domestic fowls are apt to feed as there is danger of poisoning them".

Urbahns (53) in 1920, recommends that the mash be well scattered at the rate of 5 pounds per acre and states that when properly used at this rate there is no danger of

poisoning livestock. However, he says, "It is advisable to keep poultry penned up for a few days after spreading the poison; or to feed them well in the morning if they are to run at large where the poison is being spread so that they will not pick up too many of the poisoned grasshoppers".

Fluke (15) in 1921, in his circular on grasshopper control states quite emphatically that there is no danger of livestock being poisoned from well scattered bait, but adds, "For a few days chickens should not be allowed to run in the fields where the bait has been scattered".

Granovsky (21) in 1925, in discussing the advantages of using sawdust instead of bran as a carrier of the arsenic in grasshopper baits, tells of using large amounts of the sawdust bait in fields where livestock was grazing. In this connection he states, "When bait (sawdust bait) is properly scattered there is no danger of poisoning either stock or poultry. Sawdust is not an attractive food for the animals, while the use of bran probably would have resulted in cattle mortality."

Kaupp (33), as late as 1929, in his book, "Poultry Diseases, Including Diseases of Other Domestic Birds", on page 397, repeats the statement made in his Colorado bulletin, namely, "Cases have been brought to our attention where birds had been poisoned by eating grasshoppers. The grasshoppers had been given arsenic in bran, and the birds, devouring

large numbers of them became ill, and many birds died."

Heelsbergen (25) in 1929, states that in America poisonings were noted from arsenic in which poultry was observed to eat grasshoppers that had been destroyed by baits containing arsenic. It seems probable that Heelsbergen was referring to Kaupp's statement.

The foregoing citations apparently complete the references in literature regarding the danger of poisoning birds by the use of poison bran mash, as used in the control of grasshoppers. It will be noticed that some of the authors quoted above state definitely that the danger of poisoning exists; while others, though not making definite statements, infer that the danger is present. Thus it may be seen that published opinions seem to have been about equally divided as to whether or not birds are endangered when the mash is scattered.

However, in recent years there appears to have been a decided swing of opinions, among entomologists at least, to the view that poison bran mash properly prepared and properly scattered, does not endanger poultry or wild birds at all. The writer recently sent letters of inquiry to the Entomologists of each of the State Experiment Stations and to the Federal Entomologists known to have had experience in grasshopper control, asking their opinions concerning the

danger of poisoning birds by the spreading of poison bran mash. Of 62 letters received in reply, not one of them definitely expressed the opinion that the poisoned hoppers or mash if properly scattered, would endanger poultry or birds. Also, a large number of them, particularly among those who had had much experience in poisoning grasshoppers, were very definite in their statements that there was no danger.

The following statements are taken from the unpublished letters received in reply to the above mentioned letters of inquiry.

Mr. J. R. Parker, Federal Entomologist stationed at Bozeman, Montana, writes; "During the twenty years I have been in Montana, I have seen a great many tons of poison bran mash scattered and during that time have run across only two instances of bird or chicken poisoning. In one case a garden had been heavily covered with bran mash, far more than was needed and in large lumps. A flock of yellow headed blackbirds came in and fed heavily and six or seven died in the garden. In the other case a wagon box which had been used for scattering poison bran mash was returned to the farmyard with a considerable quantity of mash scattered over the floor of the wagon box. Domestic chickens hopped into the box and cleaned up the mash. As a result, most of them died..... On no occasion have I ever seen birds or chickens poisoned when the mash was properly scattered, or from eating poisoned

grasshoppers. I have heard many such reports and have tried to trace down some of them, but the dead birds are always 'on the next farm' or 'just over the hill' when one starts looking for them.

"Mr. R. L. Shotwell, who has had a number of years of experience in grasshopper work in Montana and the Dakotas, says that the only case of poisoning he has actually seen was a turkey which gorged itself on bran mash which had been scattered in lumps. He reports that in one locality where he conducted bait tests for several weeks, a prairie chicken and her flock of young were seen on the experimental plots nearly every day and were still in the vicinity after the work was completed."

Mr. V. L. Wildermuth, Federal Entomologist at Tempe, Arizona, writes "We, too, have heard reports of this kind, but in running them down it has always been found that they were erroneous and that death was due to other causes".

Mr. Harry A. Stewart, County Agricultural Agent at Phoenix, Arizona, who had charge of the campaign in which something over 300,000 pounds of bran mash was used, writes "We have not had a single report from farmers or their neighbors that birds in their community have been poisoned from the mixture..... However, this year the State Game Warden, when he heard of our campaign, made himself clear

that he was going to check on us very carefully and if he found that our poison was killing birds, he would insist that we stop distribution. We told him that this was reasonable enough, and we continued the campaign without hearing further from the warden or his deputies. Therefore, we feel safe from the standpoint of its killing birds."

Mr. C. A. Henderson, County Agricultural Agent at Klamath Falls, Oregon, in reporting his experiences, states that in excess of 1,000,000 pounds of mash were distributed in the Tule-lake district. He writes: "We have had no authentic reports of this mash affecting wild birds or game birds. We have had a number of reports that the material was killing water fowl and turkeys, but investigation showed that this report was not true. Only in one case were there any data to the contrary. One turkey operator had some loss during the late fall that he attributed to poisoned grasshoppers. Some of the turkeys were examined but analyses of the stomach contents were not made. Inasmuch as we have had turkeys raised in other poison areas, it is questionable whether the loss was due to arsenic or not." He also reported some losses of ducks as occurring in this vicinity which had been attributed to the poison bran mash. The case seemed sufficiently serious to call in help concerning it, and summing this up, Mr. Henderson states: "The conclusion was reached a year ago

by Federal Pathologists and Entomologists studying the duck disease that the grasshopper poisoning in that territory had no bearing whatever on the sick duck situation."

Mr. J. J. Davis of Indiana writes, "We have used this material extensively in years past and only rarely have observed death of birds. In fact, the instances are so rare as to be of no significance."

Mr. T. J. Headlee of New Jersey, states: "A number of years ago when I worked for the state of Kansas we had reports of poisoning of birds from the spreading of poison bran mash for poisoning grasshoppers. Our own studies of the case at that time indicated that there was little or nothing of sound nature behind these allegations."

Mr. Stewart Lockwood, who has had much experience in poisoning grasshoppers, especially in Montana and North Dakota, writes, "In regard to the loss of bird life, there have been some instances when grasshopper poison may possibly have been responsible. However, I personally have not seen any of this and I have tramped over many grain fields where grasshopper poisoning has been reported as killing game and insectivorous birds such as grouse, horned lark, and some of the northern sparrows. There is small doubt in my mind that some meadow larks have died, but I have not been able to find a single bird whose death could be associated after

a post-mortem to arsenical poisoning. You will be interested, I am sure, to know that in the field where we worked one summer investigating this poison and were none too careful in the disposal of different baits, that after the daily experiment two sharp tailed grouse and two pheasants reared their families..... I know of one case where a farmer lost several turkeys due to grasshoppers that had been poisoned with arsenic. These had died in an irrigation ditch and when the water was turned on they floated down the ditch by the barn, collecting at the dividing gate and were scooped out into a pile. I was young at the business at that time and did not take the viscera for a chemist to analyze, but I did find that their crops were completely packed with parts of grasshoppers and that in some instances the spurs of the hind tibia had punctured their crops.

"In Montana we had more or less of a scrap on this account. An editor of a monthly farmers' magazine in playing the part of Sir Galahad in almost every issue blasted the Biological Survey and the Entomologists for the use of arsenic and strychnine which he claimed was destroying the game and insectivorous birds. He was invited time and again to produce this type of bird in which arsenic could be found on post-mortem examination. This was never done."

Mr. S. E. Piper from the Bureau of Biological Survey,

writes "Having heard that this poison bait, as exposed for grasshoppers, had in several instances killed a number of horned larks, I made several tests on these birds in the bean fields and vegetable fields of Santa Maria Valley, but with no effects of the poison becoming evident. These results are not conclusive since the horned larks in this locality had not taken grain baits."

Mr. W. J. Baerg, of Arkansas, says, "In western Kansas I have seen it used on a truck farm. The farmer kept about 500 chickens and the coops were scattered over the field for the special purpose of controlling grasshoppers. In addition he used poison bran mash liberally. He informed me that not even a baby chick suffered ill effects if kept on the ground where the poison bran mash had been scattered."

Mr. W. P. Flint, of Illinois, writes: "I have on several occasions used the poison bran bait on the University pasture both in the cattle and horse pastures. Neither cattle nor horses were removed from the pastures and no injury whatever resulted. We have checked over the vicinity of these pastures and along the hedges for dead birds without finding any such."

Mr. M. H. Swenk, of Nebraska, writes, "We have had in the past some reports of wild birds being poisoned by picking up poison bran or grasshoppers killed with poison bran,

and have in a few instances tried to verify these reports but without success. In one instance, I found that the dead birds that were being found had been killed by striking a newly placed telephone wire. I am not discrediting all of the reports that have been received, but I feel that in general, thinly spread poison bran is fairly safe."

Mr. C. C. Wilson, Federal Entomologist of Sacramento, California, writes: "We have applied poison bran bait around ranch houses where both hoppers and chickens were numerous with no casualties among fowls..... One experiment where grasshoppers were poisoned in an alfalfa field which had been harvested just previous to the application of the bait, turkeys followed us while we were sowing the bait and remained on the area where as high as 450 grasshoppers per square yard were killed, with no ill effects on the fowls."

Mr. E. G. Kelly, Extension Entomologist of Kansas, writes: "I am aware of the fact that many chickens, quail, and other birds are killed by the spreading of poison bran mash to control grasshoppers, but my personal opinion is that when these birds are killed it is because of the improper scattering of the mash."

Mr. L. P. Rockwood, Federal Entomologist at Forest Grove, Oregon, writes: "I have never observed any signs of

poisoning of birds by bran mash or by eating poisoned grasshoppers, except possibly in the one case which I will give you herewith. On August 12, 1929, I picked up a dead sparrow, which I took to be a Western Savannah sparrow, in a field where grasshoppers had been poisoned with the standard formula of bran mash containing arsenious oxide 1 pound to 25 pounds of bran. On opening this bird I found the gizzard full of a pinkish juice, probably blood, mixed with stomach contents and grasshopper legs and other hard parts, but saw no bran."

Mr. C. P. Gillette, of Colorado, says, "I cannot doubt that poultry would be poisoned by feeding upon poison bran where it is distributed in piles or in a very lumpy condition, as is sometimes the case, but I do not think there would be much danger of poisoning the birds when the arsenic bran mash is properly distributed."

Mr. C. L. Fulke, of Wisconsin, writes: "The only case we have of that nature is the case of the flock of ducks being killed where the poison bait leached into a small pond where the ducks were feeding. In this case sodium arsenite was used in the liquid form and there was no question about the cause of the death of the birds."

One of the surprising things that a review of the literature brings out is the fact that although the question of poisoning other animals constantly arises, the amount of

experimental work carried on as compared with the number of opinions that have been expressed is exceedingly small. With few exceptions, all of the statements given concerning the poisoning of fowls appear to have been based on chance observation rather than on recorded experimental work.

Washburn (55) apparently is the only American worker who has carried on any experimental work in an effort to determine what effect arsenic, as used in the control of grasshoppers, might have on poultry. He reports as follows: "It has already been definitely settled that it is extremely difficult to poison poultry with arsenic..... To bring the matter nearer home to the Minnesota farmer, this department of the station has recently made a most severe test, using a full grown turkey and full grown and two-thirds grown chickens with most satisfactory results. The conditions were much more severe in this test--which was with confined fowls, lasting over two weeks, and using meal into which some grain was introduced instead of horse manure--than could possibly exist in the use of Criddle mixture, the fowls being obliged to pick their food from this poisoned mess or go without.

"I do not hesitate to say then that the Criddle mixture is perfectly safe then in this connection as far as full grown fowls are concerned. While we have not as yet

had an opportunity of determining whether or not greedy young turkeys and chickens would succumb, it is fair to conclude that the use of Criddle mixture is also perfectly safe with them for it must be borne in mind that it is simply the particles of undigested grain which fowls seek in horse droppings, and it must further be remembered that in the majority of cases, this mixture would be used in the fields far from the houses, and consequently not in situations frequented by young chicks."

In 1911 Washburn (56) also reports on testing a formula consisting of sodium arsenite 1 pound, horse manure 120-150 pounds and 1 pint of molasses, as follows: "It was tested on poultry to see whether these animals in picking grain from such material would be injured. Two roosters were fed upon it for some time with no bad results."

These reports indicate that the experiments were not sufficiently thorough to justify the drawing of definite conclusions.

Van Zyl (54) in 1929 in South Africa carried out some much more thorough experiments. The conditions under which his work was carried on were distinctly different from those existing here. There, the common method of control is to spray the grasshoppers with sodium arsenite rather than to feed them poisoned bran.

The first part of his work consisted of determining the lethal and toxic doses of white arsenic (As_2O_3) and sodium arsenite. He first fed 75, 320 and 160 mg. of powdered white arsenic to fowls weighing 1, 1.8, and 2.25 Kg. respectively. He summarizes these cases as follows:

"From these three cases it would appear that ordinary white arsenic (insoluble) is much less poisonous for fowls than is commonly accepted for the dog or human subject (Blythe 1895), (Glaister 1921). Even horses and cattle seem to be rather less resistant (Frohner 1910, Lauder 1912). The minimum lethal dose, which very likely would vary considerably according to the individual characteristics of the bird, the fineness of the arsenic grain, the mode of administration, etc. is placed by the recorded experiments at about 7.5 gm. As_2O_3 per 100 Kg. body weight or 150 mg. (2½ grains) per average large bird of 2 Kg. (4½ lb.) live weight. This figure agrees closely with that of 0.1 - 0.15 gm. per bird (weight of birds not stated) given by Carvenin (Frohner, 1910, and Lauder 1912)."

He next fed fowls doses of sodium arsenite (80% sodium arsenite dissolved in water) in such amounts that the birds received 100, 50 and 95 mg. of As_2O_3 in this form. The birds weighed respectively 2, 1.45 and 1.85 Kg. The following is his summary of these cases:

"These three cases seem to place the minimum lethal dose of soluble arsenic for fowls at about 3.75 gms. As_2O_3 per 100 Kgs. live weight or 75 mgs. per average large bird of 2 Kgs. If we compare this figure with that for white arsenic, we see that for fowls the dissolved oxide is just twice as toxic as the insoluble oxide. It would further appear that fowls are appreciably more resistant to arsenite than sheep, horses, or cattle, as for these animals Kaufmann, Green, and others put the minimum lethal dose of dissolved As_2O_3 at about 1 gm. per 100 Kgs. body weight (Green and Dykmann, 1918)."

The next part of Van Zyl's experiment consisted of feeding smaller amounts of sodium arsenite over long periods of time, in order to determine what effect this would have on the fowls. He concluded from these experiments that birds weighing 4½ pounds, receiving small doses of soluble As_2O_3 over extended periods, may have this dose increased until they receive 45 mgs. per dose without ill effect, and that twice this amount results in death.

The next part of the work was to determine the arsenical content of the dead poisoned locusts. This work, however, was of little value to us as the method he used to poison the locusts was to spray them with sodium arsenite, which is the common method of controlling the species of locusts most destructive in South Africa. The analysis of

numerous samples of locusts showed the arsenical content to vary all the way from nothing to as high as 103 mgs. per 100 gms. of dry material. Van Zyl stated, "The latter figure was extremely high, for fresh locusts that had been very heavily sprayed for experimental purposes had an arsenical content of only 75 mgs. per 100 gms. of air dry material."

From the knowledge obtained from the first parts of this experiment, Van Zyl was able to conclude that there was slight, if any, danger to poultry from feeding on poisoned grasshoppers. However, a series of feeding tests was conducted, which he summarized as follows: "A feeding experiment on a group of seven cocks showed that locust meal prepared from locusts showing a very high arsenic content, was quite harmless, even when fed in quantities approaching one ounce per bird per day. This was the maximum amount which the birds would eat, and the daily intake of arsenic then was equivalent to 20 mgs. As_2O_3 per bird. During the period when the locust ration was about half of this, the birds put on considerable weight, proving that 10 mgs. As_2O_3 in the ration can be easily tolerated and may even be conducive to fattening. It follows then that dried locusts or locust meal showing the exceptional figure of 120 mgs. As_2O_3 per 100 gms. would still be absolutely safe as poultry food if used in quantities

up to 3 ounces weekly per average mature bird of 2 Kgs. body weight; i.e. up to twice the recommended rate. In fact, the danger to poultry of arsenic in sprayed locusts seems so small that one may be tempted to ignore it altogether. ..... We are, therefore, of the opinion that the combined evidence of the experiments described here clearly shows that the danger of feeding poisoned locusts to poultry is practically negligible."

While this information is extremely interesting and of much value to those interested in the danger of poisoning poultry from poisoned locusts, there are two important points differing from conditions here in America that render it inconclusive for our conditions. In the first place, here, rather than spraying locusts with a solution of sodium arsenite they are poisoned by feeding them the arsenic in a food medium. Second, Van Zyl investigated the danger attached to grinding the poisoned grasshoppers and feeding them to the poultry, a practice used in South Africa, while here the danger to poultry lies in their feeding upon the poison mash or the poisoned grasshoppers in the field where they die. Therefore, it was felt that further work was desirable to investigate the danger existing under our conditions.

While the danger of poisoning domestic animals other

than birds is not a part of this investigation, it is so closely related to this problem that it is thought worth while to review briefly the literature on this subject before taking up the experimental work carried on with birds.

In South Africa, Van Zyl (54) reported on a few cases of animals that were supposed to have died as a result of eating poisoned hoppers. In all but one case, the evidence was so incomplete that no deductions could be satisfactorily made. In one case, however, a heifer died and upon opening the rumen a considerable quantity of locusts was found and it was noticed that the lining of the stomach and intestines had in part been badly affected. A sample of locusts collected in the vicinity contained 78 mgs. As_2O_3 per 100 gms. of locust. Van Zyl states, "The evidence of the post-mortem makes it practically certain that death was due to arsenic." He concludes that cattle grazing on poor pastures where poisoned locusts were abundant would be likely to eat enough of them to result in death, when the locusts contained such a high per cent of arsenic. This, however, is another case in which the locusts had been killed by spraying with sodium arsenite rather than a poisoned mash and therefore is not applicable to our conditions.

Theron and Hall (52), also of South Africa, in 1924

analyzed the arsenical content of some locusts that had been poisoned by means of the following formula: 2 ounces arsenite of soda containing 80 per cent As_2O_3, 2 pounds sugar, 2 gallons water and one-half bag (size not given) barley or bran. The highest arsenical content found was 15 mgs. of white arsenic to 1 pound of dried locusts. Using this figure as a basis, together with the lethal dose of arsenic in this form, to cattle, horses and sheep, it was concluded that cattle in order to receive a toxic dose would have to eat 200-700 pounds of locusts; horses, 67-230 pounds; and sheep, over 30 pounds. From our knowledge of the food habits of these animals it would appear practically impossible for an animal to receive a lethal dose of arsenic from this source.

In their conclusion, Theron and Hall state, "It must be emphasized, however, that if the poison is used in higher concentrations than that prescribed, as is frequently done because of a desire to see the locusts die on the spot, or when locusts are sprayed with an arsenical solution even of the right strength, it may easily happen that they will then contain a sufficient amount of poison to become dangerous as a feed. The writers know of no case of poisoning in stock where poison was used according to the directions and where it was of the correct strength."

Seddon (48) in 1927, in New South Wales, carried on a series of experiments to determine the danger of sheep's being poisoned by feeding on grasshopper bait. In these experiments bait was placed before the sheep on concrete surfaces, on bare ground, and on grass covered ground, the rate running as high as 300 pounds per acre. He failed to give the formula for preparing the bait used but stated that the concentration of the poison was 1 to 53, using both sodium arsenite and Paris green as the poison. This is approximately one-half the concentration used in this country when white arsenic is used. However, since it was used at from 20 to 60 times the amount per acre, this factor is not significant. From these experiments he concluded, "that when broadcast on bare ground at the rate of 300 pounds per acre sheep may take Paris green bait in sufficient quantity to cause symptoms of arsenical poisoning - possibly even death" and "that when broadcast on pasture even at the rate of 100 pounds per acre sheep may graze over it without gathering a toxic dose."

Since in America the bait is seldom used at the rate of more than 10 pounds per acre, Seddon's experiment would seem to indicate that the spreading of grasshopper bait according to our recommendations is entirely without danger to sheep that may graze over the area.

Apparently no experimental work has been conducted in America to determine the possibility of poisoning stock from this source. However, these observations, together with experimental work conducted elsewhere, seem to indicate clearly that such danger is so exceedingly small that it is without significance. The following facts, to the writer, appear to justify this statement:

(1) Numerous workers have recorded the fact that cattle, horses, sheep, and hogs have been grazing in the pastures where the poison bran mash was spread, without any fatalities resulting. This is, of course, also true of domestic fowls and birds, but in the latter case any fatalities could have been overlooked much more easily.

(2) It is difficult to imagine stock securing the amount of arsenic necessary to kill them from poison bran mash, when it is well scattered over the ground at the recommended rate. From our knowledge of the minimum lethal dose of arsenic, for cows for instance, which, according to Theron and Hall (52) is 3 gms., we can see that it would be necessary for a cow to pick up and eat 75 gms. of the bait in order to obtain this amount of arsenic. This would be all the bran found on 5769 square feet when the mash is spread at the rate of 10 pounds per acre, assuming that 4 pounds of arsenic is used in 100 pounds of bait. According to Theron and

Hall, 3 gms. is the minimum lethal dose, while it may require as much as 10 gms. for some animals. In the latter case, it would be necessary for the animal to pick up and eat all the bait on 18,930 square feet in order to receive a lethal dose. This may be within the range of possibility, but it is so extremely unlikely that it is not of practical importance and no doubt accounts for the absence of poisoning occurring when bait has been scattered where stock was grazing.

(3) It is even more difficult to imagine the animals eating a sufficient number of grasshoppers to secure a lethal amount of arsenic. The work discussed later in this paper shows the average amount of arsenic consumed per grasshopper (Melanoplus bivittatus Say) to be .0007525 gms. which would indicate that it is necessary for a cow to eat approximately 4,000 large grasshoppers or approximately 13 pounds of grasshoppers to receive a fatal dose. From our knowledge of the food habits of cattle, this, too, seems very improbable.

It must be remembered that these statements are all based on the assumption that the bait has been thoroughly scattered. Where it is allowed to fall in lumps or piles, or where stock have access to the sacked or stored bait or mixing utensils, then there is great danger. Numerous cases

of poisoning under such circumstances have been recorded and the absolute necessity of protecting animals from such sources of danger cannot be too strongly stressed.

The amount of arsenic constituting a lethal or toxic dose to birds is another phase of interest to anyone investigating this problem.

Gallagher (18), after conducting a short series of experiments in which 3 to 4 pound hens were administered As_2O_3 in gelatin capsules arrived at the following conclusions: 1 to 3 gms. of As_2O_3 has no noticeable effect upon hens; 5 gms. constitutes a lethal dose.

Also, according to Reinhardt, Frohner states that 0.12 to 0.15 gm. of arsenic constitutes a lethal dose.

Reinhardt (46) administered 0.2 gm. without injury to birds but killed them with 0.4 gm.

Skiba (50) states that 0.06 to 0.15 per Kg. body weight is poisonous.

Heelsbergen (25) states that the lethal dose of arsenic for poultry is on the average 100 to 150 mgs. per bird.

Van Zyl (54), as reported previously in this paper, carried on a series of experiments in which 7.5 gms. As_2O_3 per 100 Kgs. body weight or 75 mgs. per bird of 1 Kg. was fatally toxic, while 7.1 gms. per 100 Kgs. or 160 mgs. per bird of 2.25 Kgs. weight was only slightly toxic. Another

series of experiments by Van Zyl, using sodium arsenite rather than white arsenic, indicated that As_2O_3 in the soluble form was twice as toxic, or that 3.75 gms per 100 Kgs body weight constituted a fatal dose.

Transposing all of these into units of milligrams, it is seen that the minimum fatal dose of As_2O_3 for chickens is placed by the different workers on the subject as follows: Gallagher, 324; Frohner, 120-150; Reinhardt, somewhere between 200 and 400; Skiba, 60-160 for a 2.2 pound chicken; Heelsbergen, 100-150; Van Zyl, 75 for a 2.2 pound chicken. Thus it appears that there is quite a wide variation in the results that these different workers obtained. There are several things that may have been responsible for this variation, a few of them being as follows: (1) Variation in the size of birds used (several of the workers failed to state the weight); (2) Variation in crop content at time of administration of poison: (3) variation in arsenic used, such as age, purity, fineness to which it had been ground, presence of lumps in it, presence of moisture, etc.; (4) variation in methods of administering the poison; and (5) varying susceptibility of the birds used.

III. EXPERIMENTAL

A. Purpose of Study

In undertaking the particular phase of the problem proposed, namely, "The Effect of Arsenic as Used in the Control of Grasshoppers upon Birds", it was desired to answer the following questions:

(1) Would the birds eat a sufficient amount of poison bait to injure or kill them?

(2) Since birds, in general, are so fond of insects, would they eat a sufficient number of poisoned grasshoppers to injure or kill them?

(3) Would the poison received by the birds from either of the above sources, have any injurious effect upon humans or other animals that might eat the birds?

In taking up the first question, consideration should be given to the source or sources from which chickens and other birds might obtain this bait.

In a general way, the sources may be divided as follows: (1) The bait may be secured at the mixing vats, due to insufficient precautions being taken to keep birds

away; (2) Very frequently, after mixing the bait, it is necessary to store it for a while before scattering and on numerous occasions birds have obtained access to the stored bait; (3) Returning containers from which the bran has been scattered to the barnyard without being properly cleaned; and (4) From the bait after it has been scattered for the grasshoppers.

In the latter case, the bait may have been scattered in piles and large lumps or it may have been scattered as it should have been, evenly and thoroughly.

In the case of the first three sources, the possibilities of poisoning are self evident and have been proven a sufficient number of times so that no further discussion is required here. Also, when bait is scattered in lumps or piles, there is no question that birds may secure lethal doses.

However, when poisoning of birds does occur from any of the first three sources mentioned, or from improperly scattered bait, it is due to carelessness of the persons handling the bait. In this work consideration is given only to the possibility of poisoning from grasshopper bait that has been properly scattered.

B. Possibility of Birds' Securing a Lethal Dose of Arsenic from Scattered Poison Bran

The previous statements given concerning the toxicity of arsenic to fowls show a wide variation in the amount of arsenic the different workers on the subject have found to constitute a lethal dose for chickens. The writer did not attempt to solve the matter of variation in the results obtained, but did consider it necessary to gather some data on the susceptibility to arsenical poisoning of the birds in the flock with which he was working.

1. Amount of poison bran constituting a lethal dose for chickens.

The birds used were from the flock of the Poultry Department of the Oklahoma A. and M. College. They were White Leghorns in good, healthy condition.

The poison, powdered white arsenic (As_2O_3), was administered in the form of poison bran mash prepared similarly to the common formula used in the preparation of grasshopper bait, except that the attrahents were left out. The formula used was at the rate of bran 96 pounds, arsenic 4 pounds, and water to moisten. Ninety-six pounds

of bran were used rather than 100 in order to facilitate figuring the percentage of poison. This same mixture of bait was used to kill grasshoppers used in another part of the experiment, in which it was thought that the attrahents should be omitted. The bran was sifted by means of ordinary window screen, having fourteen meshes per inch, in order to remove any shorts contained in it. The white arsenic was finely powdered, dry and chemically pure. The bran and arsenic were thoroughly mixed and then dampened with finely sprayed water. This mixture was then permitted to dry. All weights of bait, unless otherwise stated, refer to the weight of this mixture after it was thoroughly dried.

A careful examination of the bottom of the receptacle in which the material was stored after being dried indicated that the arsenic was adhering well to the bran as none could be found, where it no doubt would have settled had it become loosened.

a. Methods. The following technique was used in administering the poison bran to the chickens. The bran was carefully weighed and placed in a clean enameled bowl. It was then moistened with water to the approximate consistency at which grasshopper bait is scattered. It was then placed in a one-fourth inch glass tube, one end of which had been well rounded by heating in a gas flame to remove any sharp

corners. The moistened bran was then tamped lightly into place by means of a metal plunger which just fitted the inside diameter of the tube. Approximately one inch of the lightly tamped material was administered at one time, followed immediately by a like amount until all had been given. The tube was inserted into the mouth of the bird to a point just posterior to the base of the tongue and the bran forced into its throat by means of a plunger. By this method the exact amount of poison bran desired could be fed with no waste.

b. Presentation of data. Bird No. 1 - White Leghorn cock - weight, 1 lb. 7 oz. This bird was used as a check only, to determine if any ill effect might result from this method of forced feeding.

Aug. 16, 4 P. M., fed 3.8 gms. of unpoisoned bran.

Results - no ill effects of any kind were observed, the bran was swallowed with no difficulty and 30 minutes later he ate normally of other food offered. Remained perfectly normal for next few days.

Bird No. 2 - White Leghorn cock, weight, 1 lb. 6 oz.

Aug. 16, 4 P. M., fed 1.85 gms. poisoned bran.

Results - Bird fed normally 30 minutes later, fed but lightly the next morning and a very slight droopiness

could be observed. Eyes remained bright, comb and wattles normally colored. Appetite fully recovered during the afternoon. No indication of diarrhoea or inflammation of mouth, eyes, or nose. In other words, a very slight droopiness and poor appetite the following morning were the only observable results.

Bird No. 3 - White Legnorn cock, weight 1 lb. 7 oz.

Aug. 16, 4 P. M., fed 2.77 gms. poisoned bran.

Results - Fed lightly 30 minutes later, appeared slightly uneasy. Decidedly droopy next morning and refused to feed. Comb and wattles slightly bluish tinge. By afternoon of second day had developed some diarrhoea and spent most of the time sitting on floor of cage with eyes closed. Eyes, nose and mouth somewhat inflamed. At 8 A. M., Aug. 18 was found dead.

Notes of autopsy - Fatty degeneration and cloudy swelling of liver. Severe lesions in gizzard. Lungs edemic. Haemorrhagic enteritis of duodenum. Diagnosis - arsenical poisoning.

Bird No. 4 - White Leghorn cock, weight 1 lb. 10 oz.

Aug. 16, 4 P. M., fed 3.7 gms. poisoned bran.

Results - 30 minutes later refused to feed, and appeared to be slightly uneasy. Aug. 17, 8 A. M. was very

droopy, still refused food, sat on floor of cage with eyes closed. Slight diarrhoea. Aug. 18, droopy all day, refused all food, sat on floor with eyes closed. Diarrhoea pronounced. Aug. 19, found dead at 8 A. M.

Notes of autopsy - cloudy swelling of liver, kidneys show hyperemia. Haemorrhagic enteritis of duodenum. Acute inflammation of gizzard. Diagnosis - arsenical poisoning.

c. Discussion. It will be noticed that all of the birds used in this experiment were of the Leghorn variety, smaller and presumably younger than those reported on by other workers, where the size was reported. This type of bird was used for the following reasons: (1) Smaller and younger birds, according to various workers, are more likely to be susceptible to arsenical poisoning; (2) The younger, rapidly growing bird would probably eat a greater amount in proportion to its weight than a grown bird; (3) The Leghorn variety of chickens is more active, and under field conditions presumably would find and eat greater numbers of grasshoppers or larger amounts of the poison bran.

For these reasons it was thought that the chickens used in these tests would more nearly represent birds likely to be susceptible to this type of poisoning than those used by other experimenters. Thus, the desired minimum toxic or

lethal dose would be more nearly approached. The following figures indicate this result was obtained.

Since 4 per cent of the total weight of bran fed was arsenic, by multiplying the weight of bran fed by .04 the amount of arsenic received by each bird is obtained. Thus, 1.85 gms. (the amount received by Bird No. 2) x .04 = .0740 gm. or 74 mgs. In a like manner, we find that Birds No. 3 and 4 received 110 and 148 mgs. of As_2O_3, respectively.

The above figures indicate that the lethal dose for chickens weighing approximately 1½ pounds is somewhere between 74 and 110 mgs. This, it will be noticed, is but slightly higher than the minimum Skiba (50) obtained, but lower than other lethal doses as given by the above mentioned workers on the subject. Since 74 mgs. is a toxic dose for a 22 ounce (1 pound, 6 ounces) chicken, 1/22 of 74 or 3.363 mgs. equals the amount of arsenic per ounce of bird weight constituting a toxic dose. Likewise, since 110 mgs. is a lethal dose for a 23 ounce chicken, 1/23 of 110 mgs. or 4.783 mgs. equals the amount of arsenic per ounce of bird weight constituting a lethal dose.

The above method of reasoning has been used by several workers and while it is thought that it may be subject to errors, it is used in this paper for want of a better method. Other phases of the work that were being conducted

at the same time indicated that so far as this particular problem was concerned, greater accuracy was not necessary.

d. Conclusions. From the above data, the following conclusions may be drawn:

(1) The lethal dose for a 23 ounce chicken is 110 mg. of white arsenic.

(2) Seventy four mg. of white arsenic constitutes a slightly toxic dose for a 23 ounce chicken.

(3) 3.363 mg. of As_2O_3 closely approximates the amount of arsenic per ounce of bird weight constituting a slightly toxic dose.

(4) 4.783 mg. of As_2O_3 closely approximates the amount of arsenic per ounce of bird weight constituting a lethal dose.

The next experiment was carried on to determine the possibility of chickens' picking up sufficient poisoned bran to injure or kill them after it has been scattered for the grasshoppers.

2. Method of procedure.

A pen 10 by 66 feet was set up in a pasture. The ground in this pen was quite similar in regard to its covering to the usual type of ground over which grasshopper

bait is scattered. In one end the vegetation consisted of very short thin grass, in the middle were large weeds with very little vegetation under them, while in the opposite end was a heavy stand of grass. The birds were placed in this pen and left for two or three days to become accustomed to the conditions. During this time they were fed grain lightly and made to clean up all before they were fed any more. Plenty of water was kept before them at all times. Poison bran was then scattered in this pen with the chickens, as indicated in the following.

3. Presentation of data.

On Aug. 13, 6 White Leghorn cocks, weighing from 1½ to 2 pounds were placed in this pen and fed grain lightly Aug. 14 at 8 A. M. and 4 P. M. Again at 8 A. M, Aug. 15 they were fed lightly and at 4 P. M. they were fed the amount they would clean up. At 10 A. M. the next morning (Aug. 16) 16 hours later, 12.12 ounces poison bran mash was distributed evenly over the floor of the cage. The mash used in this experiment had the usual amount of arsenic in it. As in the previous experiment, this mash was prepared, allowed to dry and weighed for the experiment and moistened again before using.

The cage in which this was scattered, being 10 by

66 feet, contained 660 square feet. Forty three thousand, five hundred sixty (the number of square feet in an acre) divided by 660 = 66. Therefore, the cage contained 1/66 of an acre. Thus, 12.12 ounces of bran were distributed in the cage at the rate of 50 pounds per acre rather than the usual 5 to 10 pounds.

No other food material was placed in the cage. During the next 24 hours there was no visible evidence of any poisoning. Judging from previous experience, if any poisoning had occurred it would have become evident by this time. Absence of appetite in previous experiments was one of the first indications of poisoning so it was assumed that if any poisoning had occurred it would show up in this manner when the chickens were again fed. Therefore, at the end of 24 hours, Aug. 17, 10 A. M., mixed grain was thrown before them and all ate greedily. They were fed again that afternoon and again the following morning and each time all fed normally.

The night of Aug. 17th there was a heavy shower that beat the bran to the ground quite thoroughly.

Aug. 18th at 10 A. M. the chickens were fed as much grain as they would clean up readily. All food was then withheld until 10 A. M. Aug. 19, when 24.24 ounces of the poison mash were scattered in the pen. Thus, the chickens

had been without food for 24 hours and the mash was scattered at the rate of 100 pounds per acre. The chickens again picked lightly over the floor of the cage but no evidence of poisoning could be detected during the next 24 hours. At the end of this time, they were fed and all ate greedily and continued to feed normally.

Using the same method except that the mash was scattered only at the rate of 100 pounds per acre, the following birds were tested: 2 Rhode Island Red chickens, weighing approximately 4 pounds each; 4 White Cochin chickens, weighing approximately 3½ pounds each; 4 Buff Orpington chickens, weighing approximately 3 pounds each; 4 turkeys about 2 months old and weighing 2 pounds each; and 4 adult quail weighing approximately 9 ounces each. In no case was there any indication of poisoning.

Two White Leghorns, weighing 1½ pounds each, and 2 Rhode Island Red chickens weighing 4 pounds each, and 4 adult quail weighing approximately 9 ounces each, were also tested, using bran mash poisoned with sodium arsenite at the rate of 1 quart (2 pounds As_2O_3) per 100 pounds of bran and again no indications of poisoning occurred.

4. Discussion

In these tests the conditions were probably more

severe than would occur under field conditions, because of the following facts: (1) Under field conditions, it is unlikely that the chickens would be starved for 24 hours, on account of the fact that there is always food of various kinds to be found in the fields at the time of year grasshoppers are poisoned. (2) This being the case, the bran eaten by chickens under field conditions, probably would not be received on an empty crop, which it is thought renders it more toxic. (3) In the field it is neither necessary nor advisable to scatter the bran at the rate of more than 20 pounds per acre, and under most circumstances, 5 to 10 pounds per acre is sufficient. Thus, we see that in the pens the bran was scattered at from five to twenty times as thickly as is necessary in the field.

Since it is necessary for a 22 ounce chicken to obtain 1.85 gms. of poison bran (4 per cent arsenic) in order to obtain a toxic dose, it will be seen that when bran is scattered at the rate of 10 pounds per acre, it would be necessary for a chicken of this size to pick up and swallow an amount of bran equivalent to every flake of bran on 18 square feet of ground. While such a thing may be in the range of possibility, it seems very improbable that it would occur when the bran is well scattered. The fact that they did not obtain this amount under as severe conditions as were imposed upon them in the pens, lends much weight to this

argument.

5. Conclusions.

To the writer, the foregoing facts seem to justify the conclusion that chickens will not pick up a sufficient amount of bran to constitute a toxic dose when it is well scattered, even at the rate of 100 pounds per acre, and therefore, certainly will not when it is scattered at the recommended rates.

C. Possibility of Birds' Receiving a Lethal Dose of Arsenic Through Eating Poisoned Grasshoppers

The next part of this experiment was to determine the possibility of birds' receiving a toxic or fatal dose of arsenic by feeding upon grasshoppers that had eaten the poisoned bait. Birds, in general, are very fond of insects, eating large numbers of them, and as a result, the question has arisen numerous times, "Would not birds in eating large numbers of poisoned grasshoppers receive sufficient arsenic to poison them?" Entomologists have often observed the absence of poisoning where chickens had access to large numbers of poisoned grasshoppers, and as a result, have stated chickens will not be poisoned by this means.

However, a search of the literature reveals that very few and meager experiments have been conducted to determine definitely this point, most of the assertions apparently having been made on chance observations. To the writer it appears that in order to state definitely that poultry would not be poisoned from eating poisoned grasshoppers, it would necessarily have to be assumed that, first, the conditions were most favorable for the poisoning of poultry at the time the observations were made; and second, that no case of poisoning could possibly have escaped notice, Under field conditions, which seem to have been the conditions under which these observations were made, it seems that neither of the above assumptions would be quite justifiable. Numerous factors might vary that would tend to influence the first assumption. Among these are (1) Amount of other food available; (2) age of poultry; (3) distance of poisoning operations from poultry; (4) number of chickens ranging over a given area; (5) the number of poisoned grasshoppers in this area; (6) variations in the amount and kinds of poison used in the bait and (7) crop content of chickens at the time grasshoppers were eaten.

The second assumption under many circumstances would scarcely be justifiable because of the many places existing

on most farms where poisoned poultry could die and not be found until several days later, or perhaps never. As before stated, Kaupp (32) records cases of poisoning and death of fowls from this source. Therefore, it was felt that more definite data concerning this point were desirable.

In working on this phase of the problem, it was considered desirable to answer the following questions:

(1) How much would be the average amount of arsenic consumed by each species of grasshopper used in the experiment, when fed upon the commonly used arsenical bait?

(2) How many poisoned grasshoppers would the chickens consume? The answer to these two questions would answer the third,

(3) How much arsenic would the chickens thus obtain?

(4) Would this amount constitute a lethal or toxic dose?

(5) If not, what effect would the poisoned grasshoppers have on the chickens,

(a) if fed in large numbers to chickens unaccustomed to such a diet?

(b) if fed over a long period of time, would the arsenic have a cumulative effect?

(6) Would the poison affect their growth? If so, how?

The species of grasshoppers used in these experiments were Melanoplus bivittatus (Say), Melanoplus femur-rubrum (De Geer) and Melanoplus bispinosus (Scudder), as determined by Mr. A. N. Caudell of the U. S. Bureau of Entomology. They were selected because they were most available. The first two named are very frequently the species causing the most damage during grasshopper outbreaks, which seemed to make them a logical choice for such an experiment.

1. Methods and apparatus.

After trying several plans, the following method of handling the grasshoppers was adopted as being most satisfactory. They were caught in a "hopper dozer", which was operated by means of a Ford car. Figures 1 - 6 illustrate the construction and operation of the "hopper dozer".

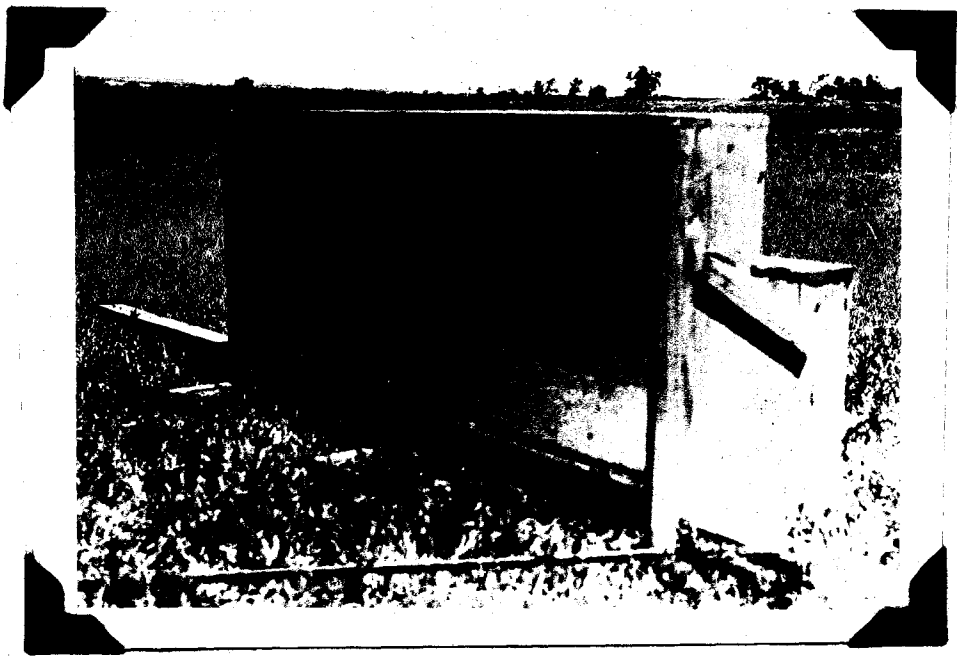

Fig. 1. Dozer Used in Catching Grasshoppers.

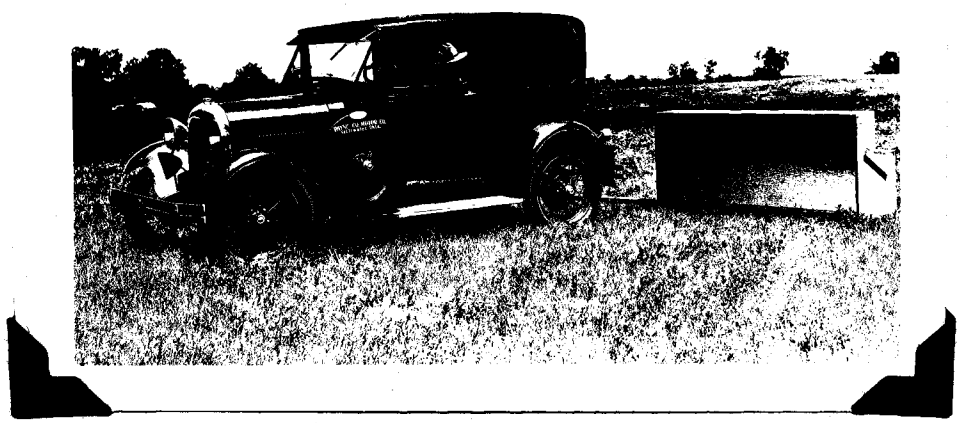

Fig. 2. Hopper Dozer Attached to Car.

Fig. 3. Diagram Illustrating Attachment of Hopper Dozer to Car.

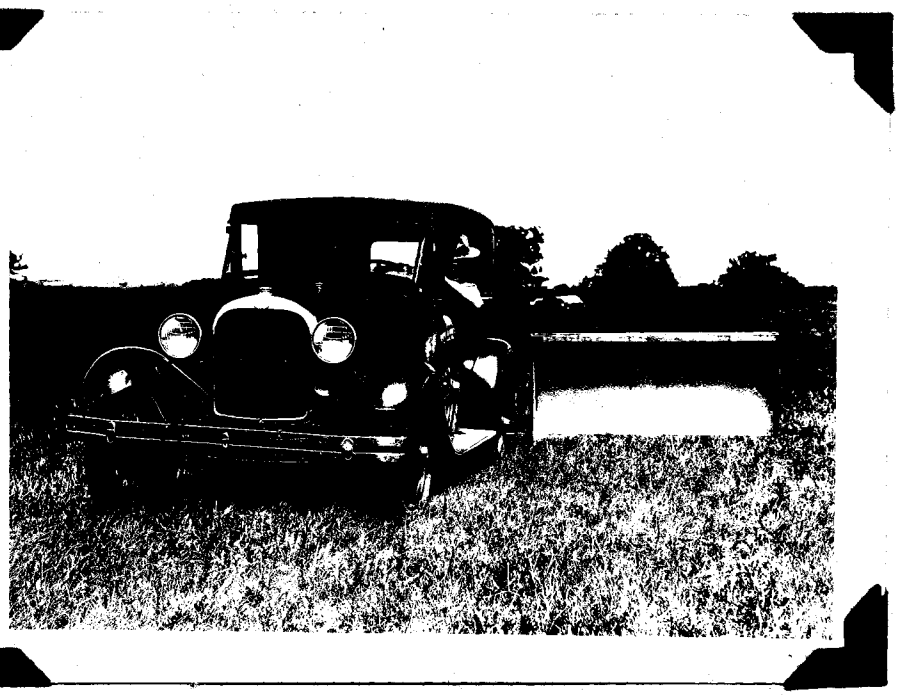

Fig. 4. Front View of Hopper Dozer Attached to Car.

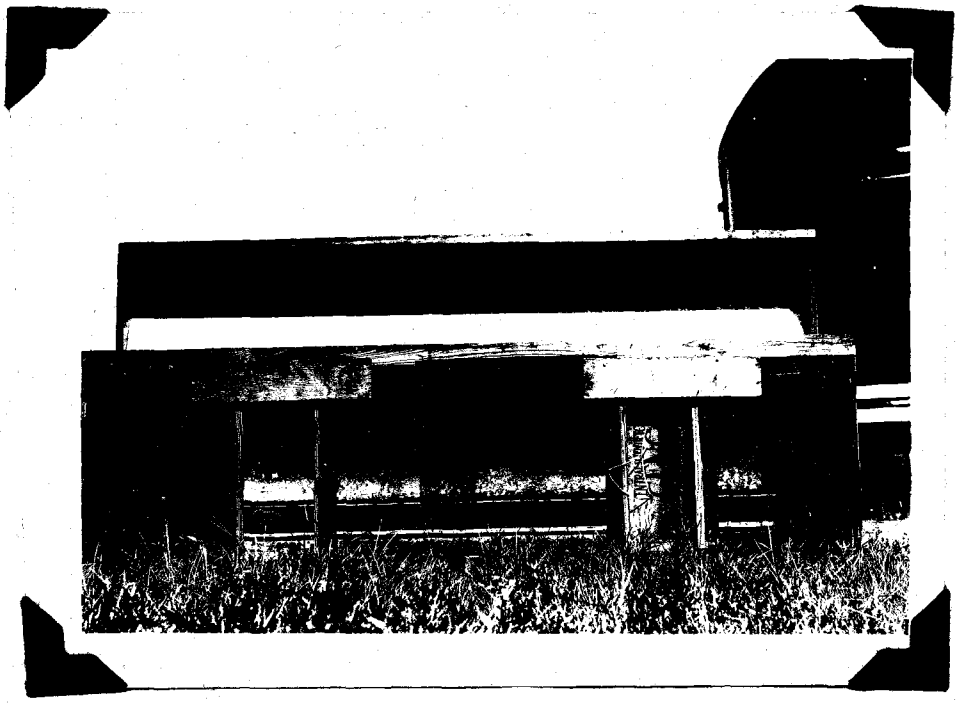

Fig. 5. Rear View of Hopper Dozer - One Door Open, The Other Closed.

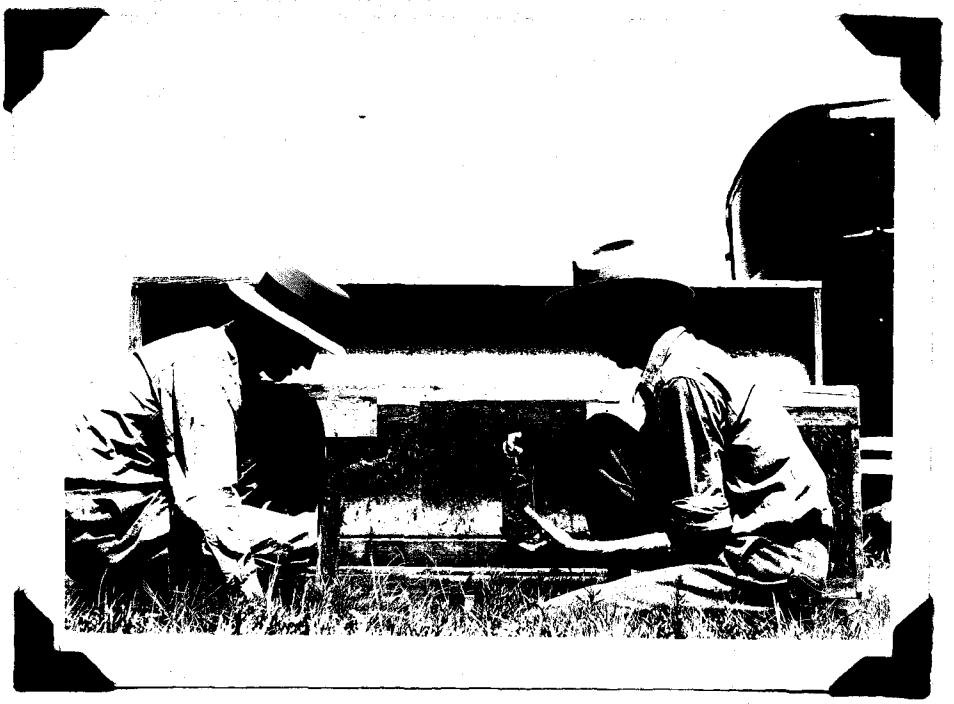

Fig. 6. Removing Grasshoppers from Dozer.

After the grasshoppers were removed from the dozer, they were placed in wire cloth cages, which were constructed as follows: Wire cloth strips 12 by 6 inches were cut. Each end of a 6 by 12 inch wire cloth strip was tacked to a one-half inch board, 5½ by 1 inch in size, in such a manner that the board came inside the resulting cylinder. Corrugated cardboard circles were then cut and fitted into the ends of the cylinder. They were fastened in place by means of fine wires, thrust through the meshes of the wire cloth, and the corrugations of the cardboard. One of the end pieces was fastened in place rigidly by means of the two wires. Only one wire was used in the opposite end, which acted as a hinge, allowing the end piece to turn in such a manner as to open that end of the cage. A small hole of the proper size to admit the species of grasshopper used was cut in one end of the cage. A cork was used to plug this hole.

Fig. 7. Cages Used in Transporting Grasshoppers from Dozer.

As the grasshoppers were removed from the dozer, the head and thorax were thrust through this hole and the hopper would then either jump or crawl into the cage of his own accord. (See fig. 6) In this manner, 20 to 50 hoppers of a single species were placed in each cage and transported to the larger cages where the other parts of the experiment were conducted. It was found that in such cages the hoppers could be confined for several hours without undue mortality occurring.

a. Determination of amount of arsenic consumed by grasshoppers. To determine the average amount of arsenic consumed by each species of grasshopper used, it was necessary to learn how much poisoned bran they would eat. It was first planned to feed a weighed amount of bran to the grasshoppers and then weigh the amount remaining after they had been killed. This, however, did not prove to be practical because (1) the dry weight of the bran had to be used; otherwise there would be too great a variation in the water content. In view of the fact that under field conditions the bran is fed moist, it was felt that it should be fed moist during the experiment. (2) Small bits of bran were lost and faeces and dirt became mixed with that remaining.

(1) Methods. To avoid these difficulties the following plan was devised. A standard size of bran

flake was selected. This was a large easily handled flake, and only flakes very nearly this size were used. In counting them, when it was necessary or convenient to select one somewhat larger than this standard the next one selected would be slightly smaller than the standard, which selection resulted in keeping variations to a low point. One hundred flake samples were weighed in order to determine the average weight of flakes of this size. These weighings resulted as follows:

TABLE I

WEIGHT OF HUNDRED FLAKE SAMPLES OF BRAN

Sample No.	Weight in gms.	Sample No.	Weight in gms.
1	0.232	6	0.231
2	0.225	7	0.238
3	0.241	8	0.239
4	0.228	9	0.238
5	0.233	10	0.232

The above table showed the total weight of the ten samples to be 2.337 gms. and the average weight of each sample was .2337 gm. Since these were 100 flake samples, .2337 ÷ 100 = .002337 gm., which is the average weight of each flake of bran of the standard selected. These weighings show a variation of only .016 gm. between the heaviest and the lightest

sample, and indicate that the amount of bran used by this method may be kept quite constant.

The poisoned bran used in the experiment was the same as that described for the previous experiment and therefore contained 4 per cent arsenic. Therefore, .04 of .002337 or 0.00009340 gm. is the average amount of arsenic on each bran flake. By determining the number of flakes the average grasshopper would eat, the amount of arsenic consumed could be obtained by multiplying the number of flakes eaten by the amount of arsenic found on each flake.

The number of flakes eaten was obtained as follows: Single grasshoppers of each species used were placed in small screen cages, together with a certain number of bran flakes.

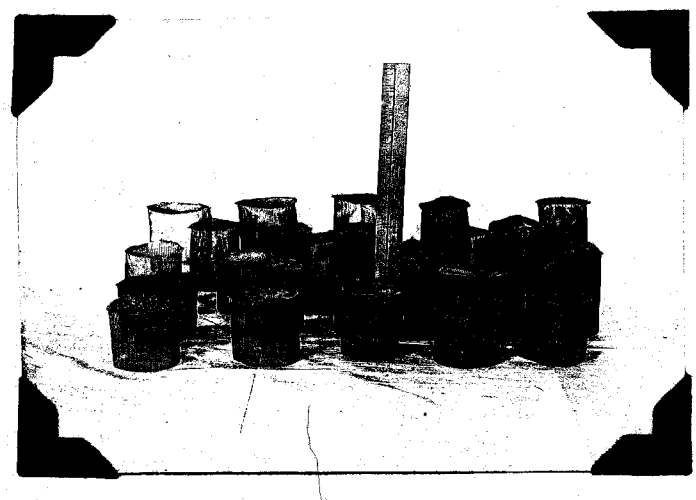

Fig. 8. Individual Cages Used for Determining Amount of Poison Bran Grasshoppers Eat.

It was learned that approximately 15 flakes was the maximum number that the larger species, M. bivittatus, would eat, while 10 or less was the maximum number for the smaller species. Therefore, 15 flakes were placed in the cages with the larger species and 10 with the others. The cages were observed twice daily and the number of flakes remaining at the grasshopper's death recorded. Then this number subtracted from the original number gave the number of flakes eaten by that particular individual.

The soil, on which the cages were to be placed, was dampened sufficiently to thoroughly moisten blotting paper placed upon it. Small squares of blotting paper were then placed upon the soil and the bran flakes were distributed evenly over the surface. This resulted in the bran flakes being in a moist, attractive condition. The cage was then placed over the bran flakes and the grasshoppers were introduced. Only adult grasshoppers were used.

Tables Nos. II, III and IV show the results obtained from this experiment.

(2) Presentation of data.

TABLE II.

NUMBER OF FLAKES OF POISONED BRAN EATEN BY M. BIVITTATUS.

Hopper No.	No. Flakes Eaten	Hopper No.	No. Flakes Eaten	Hopper No.	No. Flakes Eaten	Hopper No.	No. Flakes Eaten
1	6	26	8	51	3	76	11
2	8	27	13	52	9	77	9
3	5	28	6	53	6	78	9
4	10	29	9	54	10	79	6
5	7	30	7	55	2	80	3
6	8	31	3	56	5	81	10
7	3	32	6	57	14	82	4
8	5	33	9	58	4	83	9
9	6	34	5	59	7	84	3
10	10	35	3	60	12	85	10
11	4	36	6	61	3	86	6
12	11	37	1	62	12	87	12
13	12	38	7	63	6	88	5
14	7	39	4	64	15	89	9
15	7	40	12	65	7	90	7
16	12	41	7	66	5	91	10
17	8	42	6	67	6	92	5
18	15	43	8	68	13	93	10
19	2	44	4	69	8	94	8
20	7	45	8	70	15	95	6
21	15	46	9	71	13	96	12
22	5	47	9	72	7	97	10
23	15	48	7	73	15	98	8
24	11	49	5	74	13	99	14
25	7	50	13	75	14	100	9

Total flakes eaten - 805
Average - 8.05 flakes

TABLE III.

NUMBER OF FLAKES OF POISONED BRAN EATEN BY M. FEMUR-RUBRUM

Hopper No.	No. Flakes Eaten	Hopper No.	No. Flakes Eaten	Hopper No.	No. Flakes Eaten	Hopper No.	No. Flakes Eaten
1	3	26	3	51	2	76	2
2	3	27	5	52	3	77	3
3	4	28	2	53	4	78	5
4	2	29	3	54	5	79	1
5	1	30	4	55	8	80	3
6	5	31	1	56	1	81	2
7	2	32	4	57	3	82	4
8	4	33	2	58	1	83	1
9	4	34	4	59	3	84	3
10	1	35	2	60	1	85	4
11	2	36	5	61	4	86	5
12	3	37	1	62	3	87	3
13	1	38	4	63	2	88	1
14	3	39	1	64	4	89	2
15	3	40	2	65	3	90	3
16	5	41	4	66	2	91	1
17	2	42	2	67	4	92	4
18	4	43	2	68	5	93	5
19	6	44	2	69	5	94	2
20	2	45	4	70	3	95	4
21	2	46	3	71	2	96	5
22	3	47	5	72	7	97	2
23	4	48	4	73	1	98	4
24	2	49	3	74	5	99	3
25	3	50	2	75	2	100	2

Total flakes eaten - 302
Average - 3.02 flakes

TABLE IV.

NUMBER OF FLAKES OF POISONED BRAN EATEN BY M. BISPINOSUS.

Hopper No.	No. Flakes Eaten	Hopper No.	No. Flakes Eaten	Hopper No.	No. Flakes Eaten	Hopper No.	No. Flakes Eaten
1	2	26	1	51	2	76	3
2	3	27	6	52	3	77	2
3	1	28	2	53	8	78	3
4	4	29	2	54	2	79	5
5	6	30	1	55	2	80	2
6	1	31	3	56	2	81	7
7	3	32	5	57	4	82	2
8	4	33	2	58	2	83	3
9	2	34	4	59	5	84	2
10	4	35	1	60	2	85	4
11	2	36	6	61	3	86	3
12	5	37	2	62	6	87	5
13	1	38	3	63	2	88	1
14	2	39	2	64	5	89	7
15	5	40	3	65	2	90	3
16	3	41	2	66	3	91	3
17	2	42	4	67	3	92	2
18	3	43	1	68	1	93	1
19	2	44	5	69	4	94	3
20	2	45	3	70	7	95	4
21	9	46	2	71	3	96	2
22	1	47	4	72	5	97	5
23	4	48	3	73	3	98	2
24	2	49	2	74	8	99	3
25	3	50	3	75	6	100	3

Total flakes eaten - 320
Average - 3.2 flakes

(3) Discussion. These tables show that the total number of bran flakes eaten by the 100 individual M. bivittatus is 805 or an average of 8.05 flakes for each individual. Likewise, 3.02 is the average number eaten by M. femur-rubrum and 3.20 for M. bispinosus. Since 0.00009348 gms. is the amount of arsenic on one flake of bran, 8.05 times 0.00009348 or 0.0007525 gms. is the average amount of arsenic consumed by each M. bivittatus. In a like manner, it is seen that .0002804 and .0002991 gms. is the average amount consumed by each M. femur-rubrum and M. bispinosus, respectively.

It may occur to the readers of this paper that a simpler and perhaps better method of approach to this problem would be a chemical analysis of the poisoned hoppers, to determine the amount of arsenic they contained. However, it was desired to determine the maximum amount of arsenic that chickens might obtain under most favorable conditions from feeding upon poisoned grasshoppers. In view of the fact that some of the grasshoppers might throw off a part of the poison in their faeces before death, it was felt that the amount they consumed rather than the amount any particular sample might contain, would more nearly represent the desired maximum amount. Some of the hoppers lived 3 or 4 days after eating the poison, others died the same day. Under these

conditions, it seems probable that chickens eating hoppers that died quickly might obtain more poison than those feeding upon hoppers that had defecated several times between the time of feeding and death.

As a matter of fact, a chemical analysis of some poisoned hoppers was made later. In connection with an experiment to be described later in this paper, portions of the bodies of chickens that had fed upon poisoned grasshoppers were sent to the office of the U. S. Food and Drug Administration at Kansas City, Mo., for a chemical analysis of arsenical content. At the time this material was prepared for shipment (January, 1930) 72 poisoned grasshoppers (M. bivittatus), all that were available at that time, were included. These were divided into two groups for analysis; the first group contained 45 hoppers, the second 27. The arsenical content of the first group was found to be 30 mgs; the second 24 mgs. According to the figures obtained in this work, the 45 hoppers would have consumed 33.8625 mgs., which is 3.8625 mgs. more than was actually found; and the 27 hoppers would have consumed 20.3175 mgs., which is 3.6825 mgs. less than was actually found. However, according to figures of this experiment the 72 hoppers would have consumed 72 x .7525 mg. or 54.18 mgs. while the total of the above two groups is exactly 54 mgs.

The fact that each method obtained such similar results indicates that the method herein used was quite accurate; and also, that little or no arsenic is thrown off by grasshoppers in the process of defecation, after having fed upon poison bran mash containing 4 per cent arsenic.

Another possibility that may occur to the readers of this paper is that a large variation might occur according to the age of the grasshoppers used. Consideration was given this phase of the problem, but Langford's (34) work in Colorado indicated the age of grasshoppers does not influence the amount of food they take; and therefore it was not considered necessary to investigate further this phase of the problem.

(4) Conclusions. The following figures at least very closely approximate the amount of arsenic the average grasshopper will consume when feeding on poison bran mash with no other food available.

M. bivittatus - .7525 mg.

M. bispinosus - .2991 mg.

M. femur-rubrum - .2804 mg.

b. Method of handling grasshoppers for tests in feeding birds. The next experiment consisted of feeding poisoned grasshoppers to the experimental birds in order to

determine the number of grasshoppers they would eat, the amount of arsenic thus obtained, and its effect upon them.

As the grasshoppers were brought in from the field, they were placed in cages 12 by 12 by 12 inches in size, constructed of 1 by 3 inch boards and ordinary window screen. The wooden frames were covered on 5 sides with screen, the sixth side being placed on the ground and serving as the floor. In the center of the side opposite the floor a hole was cut, sufficiently large to admit the hand and arm. Adhesive tape was placed around the edge of this hole to prevent scratching of skin while handling material within the cage. To close the cage, squares of screen were placed over the holes and weighted with flower pots. Some of these cages were placed in the greenhouse, others out of doors.

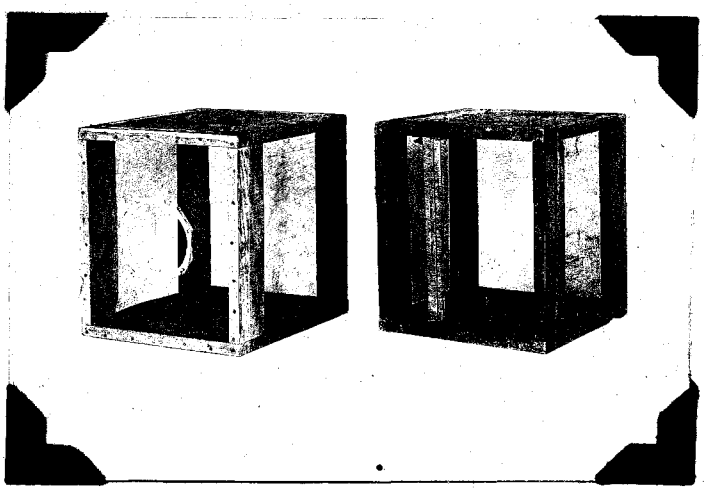

Fig. 9. Showing Construction of Cages in Which Grasshoppers Were Poisoned.

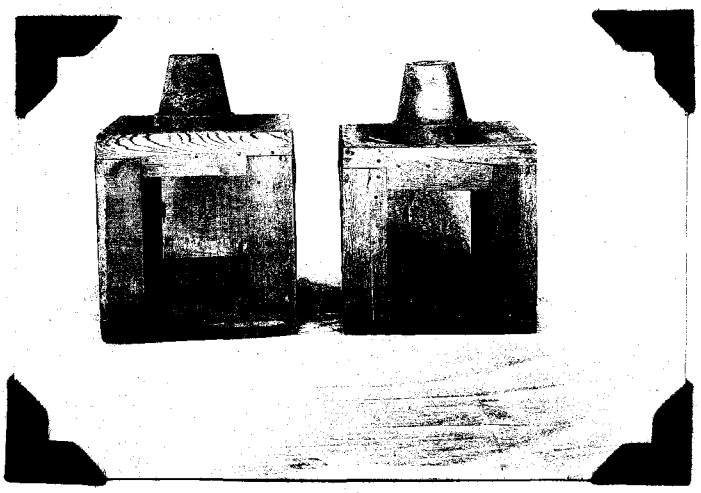

Fig. 10. Cages Used for Poisoning Grasshoppers.

The cages were placed in pairs. In one cage of each pair, poison bran mash (from the same mix already described) was placed; in the other, bran, treated the same as the poisoned bran except that no poison was placed in it. At first 20 hoppers, all of the same species, were placed in each cage; later it was found that the same results could be obtained by placing 50 in each cage. The use of 50 grasshoppers per cage made it possible to handle larger numbers of hoppers with the same number of cages so the larger number was placed in each cage most of the time. Different species of grasshoppers were used in different pairs of cages.

At the beginning of the experiment, it was decided to use for feeding purposes only those grasshoppers in which 90 per cent of those in the poison cage died while 90 per cent

of those in the check cage were still alive. But early in the season there was considerable cloudy weather. Under such conditions it was very difficult to secure a 90 per cent kill in the poison cages before 10 per cent of the checks died. As a result, the greater number of all hoppers collected had to be discarded, making it extremely difficult to keep sufficient poisoned hoppers to keep the feeding experiments going. Therefore, it was decided to use in the feeding experiments grasshoppers where 75 per cent of those in the poison cages were killed while 75 per cent of the checks were still alive. It is interesting to note that very little cloudy weather occurred after this plan was adopted and a high percentage of the grasshoppers fed were poisoned.

Two to six hours after the grasshoppers were placed in the cages, all dead ones were removed and discarded, it being assumed that such deaths were more likely to be due to mechanical injury suffered in catching and handling them rather than to poisoning.

It was assumed that the same number in the poison cage died from some cause other than poisoning that died in the check cage. Therefore, it was figured that the number dead in the poison cage minus the number of dead in the check cage, had been killed from the poison. Thus, if 25 were

dead in the poison cage and 5 in the unpoisoned cage, the 25 hoppers were fed to the chickens but recorded as if only 20 had been fed. The same results were obtained by recording the per cent poisoned, and it was found more expedient to keep the records in this manner so this was the plan used. Under the plan, in the above circumstance, the 25 hoppers would be fed and recorded as 25 hoppers 80 per cent poisoned, which, of course, would be the equivalent amount of poison found in 20 hoppers 100 per cent poisoned. Then in figuring the amount of arsenic eaten, 80 per cent of 25 times the average amount of arsenic eaten by a single grasshopper of that particular species was considered to be the amount eaten by the fowl.

From one to three or four days were required to kill the grasshoppers. To prevent decomposition of those that died first, all dead hoppers in each cage were removed each morning and afternoon. Notes were made of the number removed and they were then placed in an electric ice box at a temperature of 35° F. until the last ones were removed and the percentage of poisoning figured. As a matter of fact, all were kept in the ice box from shortly after death until used. By this method, all were kept in good condition so that it was not necessary to feed partially decomposed grasshoppers.

In using this plan, it will be noticed that conditions were made as favorable as possible for poisoning of

chickens as it seems probable that grasshoppers with no other type of food available would consume more poison than those under field conditions where so much other food could be obtained.

2. Presentation of data.

a. Experiments in feeding poisoned grasshoppers to chickens. In view of the fact that the younger, rapidly growing chickens eat a larger amount of food in proportion to their weight than the larger, more mature chickens and that their digestive tract has had less contact with any foods that might have some corrosive or toughening action, it seems probable that they might be more susceptible to arsenical poisoning. Therefore, an experiment was conducted with the youngest chicks available at that time. These chicks were Brahmas two weeks old and weighed as follows: No. 29 - 2.40 oz.; No. 30 - 2.25 oz.; No. 31 - 2.20 oz.; and No. 32 - 2.40 oz. Nos. 29 and 30 were fed poisoned grasshoppers, Nos. 31 and 32 unpoisoned grasshoppers. Growing ration developed at the Agricultural Experiment Station of Oklahoma A. and M. College was kept before them at all times. It was made up of the following ingredients: 125 pounds yellow corn meal, 125 pounds shorts, 125 pounds bran, 35 pounds alfalfa meal, 25 pounds meat scraps, 25 pounds cotton

seed meal, 25 pounds dried buttermilk, 7.5 pounds bone meal, 3.75 pounds salt and 3.75 pounds limestone.

The grasshoppers were cut into three pieces before feeding until the chicks were sufficiently large to swallow whole grasshoppers easily, after which the hoppers were fed whole. When the chicks were first caged and grasshoppers placed before them, they did not eat them readily. Therefore, they were fed unpoisoned grasshoppers for four days before the experiment was started. During this time, it was noticed that Nos. 29 and 31 ate more than Nos. 30 and 32; therefore, one of the heavier and one of the lighter feeding chickens were placed in each cage.

The chickens eating poisoned grasshoppers were given all they would eat, the others fed approximately the same number. They were fed twice daily. At the close of the experiment, they were killed and autopsied. Table V gives the data concerning this experiment.

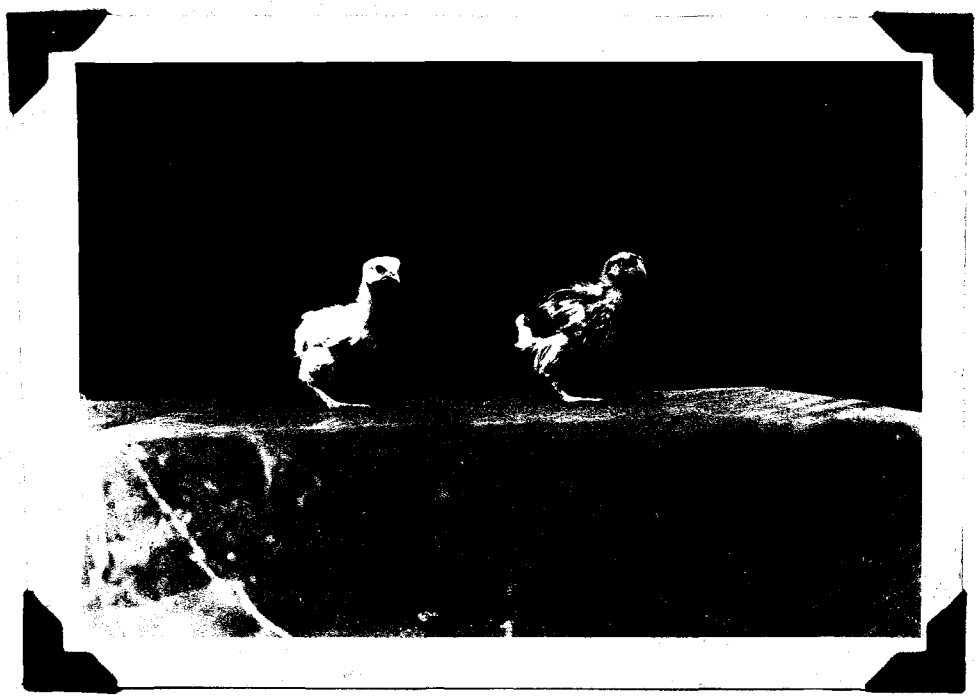

Fig. 11. Chickens Nos. 29 and 30 at Beginning of Experiment.

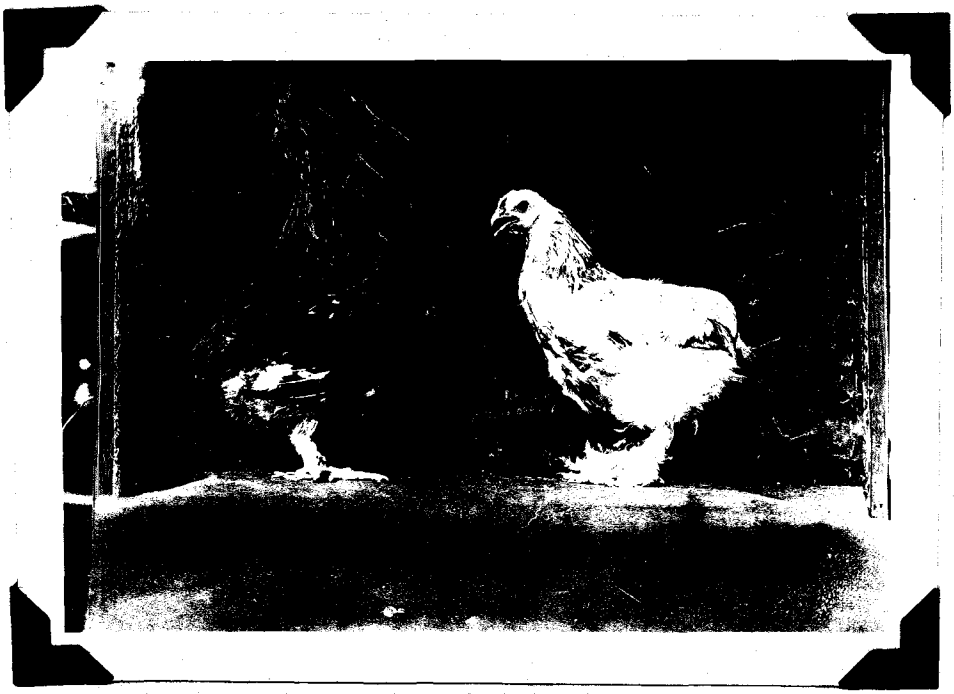

Fig. 12. Chickens Nos. 29 and 30 after Feeding Daily for 66 Days on Poisoned Grasshoppers.

TABLE V.

DATA ON FEEDING GRASSHOPPERS AND GROWING RATION TO CHICKENS.

	Chickens Nos. 29 and 30 eating hoppers poisoned with white arsenic and bran					Chickens Nos. 31 and 32 eating unpoisoned hoppers	
Date	Species Hopper	No. eaten	% Poisoned	Amount Arsenic in mgs.	Weight	No. eaten	Weight
6-17	M. bis.	10	80	2.3928	4.65 oz.	10	4.60 oz.
6-18	" "	9	80	2.1535		9	
6-19	" "	7	84	1.7587		7	
6-20	M. fem.	9	94.5	2.3848		9	
6-21	" "	9	83.3	2.1022		9	
6-22	M. bis.	9	87.5	2.3554		9	
6-23	M. fem.	10	77.7	2.1787		10	
6-24	M. bis.	8	92.7	2.2181	7.04 oz.	8	6.55 oz.
6-25	" "	5	100	1.4955		5	
6-26	" "	4	95	1.1364		4	
6-27	" "	5	95	1.4207		5	
6-28	" "	4	86.6	1.0361		4	
6-29	M. fem.	3	95	0.7991		3	
6-30	M. bis.	2	95	0.5683		2	
7-1	" "	3	95	0.8584	9.2 oz.	3	9.5 oz.
7-2	" "	3	90	0.8076		3	
7-3	" "	3	90	0.8076		3	
7-4	" "	3	86.6	0.7771		3	
7-5	" "	3	100	0.8973		4	
7-6	" "	4	100	1.1964		4	
7-7	" "	6	92.3	1.6564		6	
7-8	" "	10	100	2.9910	12.0 oz.	10	13.3 oz.
7-9	" "	8	82.3	1.9693		8	
7-10	" "	8	87.6	2.0967		8	
7-11	" "	10	100	2.9910		10	
7-12	" "	8	88.2	2.1104		10	
7-13	" "	6	90	1.6151		8	
7-14	" "	5	100	1.4955		8	
7-15	M. biv.	4	100	3.0100	16.0 oz.	4	17.7 oz.
7-16	" "	2	88.2	1.3274		5	
7-17	M. bis.	4	100	1.1964		4	

TABLE V.

DATA ON FEEDING GRASSHOPPERS AND GROWING RATION

TO CHICKENS (Cont'd)

Chickens Nos. 29 and 30 eating hoppers poisoned with white arsenic and bran						Chickens Nos. 31 and 32 eating unpoisoned hoppers	
Date	Species Hopper	No. eaten	% Poisoned	Amount Arsenic in mgs.	Weight	No. eaten	Weight
7-18	M. biv.	4	94.3	1.1282		5	
7-19	" "	5	90	3.3863		4	
7-20	M. bis.	4	80	0.9571		4	
7-21	M. biv.	4	100	3.0100		4	
7-22	" "	4	100	3.0100	28.0 oz.	4	23.4 oz.
7-23	" "	4	100	3.0100		5	
7-24	" "	4	94.7	2.8505		5	
7-25	" "	8	94.7	5.7010		6	
7-26	" "	4	100	3.0100		5	
7-27	" "	5	100	3.7825		5	
7-28	" "	4	94.7	2.8505		6	
7-29	" "	7	94.7	4.9883	29.0 oz.	6	31.5 oz.
7-30	" "	6	100	4.5150		6	
7-31	" "	6	100	4.5150		11	
8-1	" "	5	95	3.5744		9	
8-2	" "	6	95	4.2882		7	
8-3	" "	7	95	5.0040		10	
8-4	" "	6	100	4.5150		8	
8-5	" "	7	100	5.2675	38.0 oz.	9	41.0 oz.
8-6	" "	5	95	3.5744		8	
8-7	" "	6	100	4.5150		9	
8-8	" "	5	94	3.5367		10	
8-9	" "	9	100	6.7725		12	
8-10	" "	7	96	5.0568		6	
8-11	" "	10	100	7.5250		10	
8-12	" "	12	94.7	8.5514	46.0 oz.	15	50.0 oz.
8-13	" "	10	93.2	7.0133		12	
8-14	" "	6	100	4.5150		10	
8-15	" "	10	100	7.5250		10	
8-16	" "	10	94.7	7.1262		10	

TABLE V.

DATA ON FEEDING GRASSHOPPERS AND GROWING RATION

TO CHICKENS (Cont'd)

Chickens Nos. 29 and 30 eating hoppers poisoned with white arsenic and bran						Chickens Nos. 31 and 32 eating unpoisoned hoppers	
Date	Species Hopper	No. eaten	% Poisoned	Amount Arsenic in mgs.	Weight	No. eaten	Weight
8-17	M. biv.	8	100	6.0200		8	
8-18	" "	9	95	6.4239		9	
8-19	" "	8	100	6.0200	58.1 oz.	9	60.0 oz.
8-20	" "	6	95	4.2893		10	
8-21	" "	8	100	6.0200		10	
8-22	" "	2	100	1.5050	65.0 oz. gain	8	66.0 oz. gain
Total:		415		27.1303	60.35 oz.	481	61.40 oz.

An illustration of the method of determining the amount of arsenic eaten each day is as follows:

On June 17 chickens Nos. 29 and 30 ate 10 grasshoppers of the species M. bispinosus. As shown on page 75, the average amount of arsenic consumed by each hopper of this species is .2991 mg. Therefore, 10 grasshoppers would have consumed 2.9910 mg. of arsenic. But in this case, 20 per cent of the grasshoppers in the check cage died, therefore it is assumed that 20 per cent of those in the poison cage died from some other cause than poisoning. Therefore, 80 per cent of 2.9910 or 2.3982 was the amount of arsenic contained in these 10 grasshoppers.

This method no doubt is inaccurate in specific cases, but over a large number of cases probably approximates the amounts quite accurately.

Notes - Without exception, after the second day, Nos. 29 and 30 were slower in eating the grasshoppers. At almost every feeding it appeared that Nos. 30 and 31 would have eaten more hoppers had they had the opportunity. At no time during the entire experiment did any chicken show any symptom of poisoning.

Notes of autopsy*- No. 29 - very mild enteritis of duodenum, slight ulceration of gizzard.

*In all notes of autopsy, only abnormal conditions are noted.

No. 30 - moderate enteritis of intestines.

No. 31 - mild enteritis of intestines, bones poorly developed.

No. 32 - lungs slightly edematous, musculature somewhat translucent.

Comments. The autopsy indicates that the arsenic may have caused a slight ulceration of the gizzard and possibly enteritis of intestines, although No. 31, which received no arsenic, also had slight enteritis of intestines. It seems possible, although scarcely probable, that the continued consumption of small amounts of arsenic may have been responsible for this condition rather than the amount they received in any 3 or 4 days, as would more likely have been the circumstances under field conditions. Also the gain in weight indicates that the condition was of relatively small importance.

As shown on page 54, 3.363 mg. per ounce of bird weight constitutes a slightly toxic dose and 4.7836 mg. per ounce of bird weight a lethal dose. As before stated, it is realized that these figures may not hold true for all weights and varieties of chickens but should approximate the toxic or lethal dose per ounce of bird weight.

Since at the beginning of this experiment, Birds 29 and 30 weighed 4.65 ounces, 4.65 x 3.363 mg. equals 15.638 mgs. or the amount of arsenic constituting a slightly

toxic dose for these birds. Any amount under this certainly could not be considered dangerous. According to Table V, 2.3928 mg. was the greatest amount of arsenic they received any one day; therefore the factor of safety for any single day was 15.638 ÷ 2.3928 or 6.5 to 1. By this same method we find the factor of safety for each week to have been as follows:

TABLE VI.

WEEKLY PERCENTAGE OF TOXIC DOSE CONSUMED BY CHICKENS.

Chickens Nos. 29 and 30

	Amount of arsenic slightly toxic	Largest amount received any day	% toxic dose	Factor of safety
1 st week	15.6379	2.3928	15.30	6.5 to 1
2nd week	23.6755	2.2181	9.37	10.7 to 1
3rd week	30.9396	1.6564	5.35	18.7 to 1
4th week	40.3560	2.9910	7.41	13.5 to 1
5th week	53.8080	3.3863	6.29	15.9 to 1
6th week	73.9860	5.7010	7.70	12.9 to 1
7th week	97.5270	5.0040	5.13	19.5 to 1
8th week	127.7940	7.5250	5.89	17.0 to 1
9th week	154.6980	8.5514	5.53	18.1 to 1
10th week	195.3903	6.0200	3.08	32.5 to 1

This table indicates that the first day the chickens were fed they came the nearest to receiving a toxic dose, and on this day received only 15.30 per cent of the amount considered slightly toxic. Thereafter, the factor of safety increased, though not regularly.

The weekly gain in ounces of the two cages was as follows:

TABLE VII.

WEEKLY GAIN OF CHICKENS

	Weekly gain, in ounces, Birds 29 and 30	Weekly gain, in ounces, Birds 31 and 32
1st week	2.39	1.95
2nd week	2.16	2.95
3rd week	2.8	3.8
4th week	4.0	4.4
5th week	6.0	5.7
6th week	7.0	8.1
7th week	9.0	9.5
8th week	8.0	9.0
9th week	10.1	10.0
10th *	6.9	6.0
Total gain	60.35	61.40

This table shows the chickens eating poisoned grasshoppers to have gained more than the others the first, fifth, ninth and tenth weeks, while the unpoisoned cage gained more the second, third, fourth, sixth, seventh and eighth weeks. However, the total gain for the chickens eating the unpoisoned grasshoppers was but 1.05 ounces greater than the ones eating poisoned grasshoppers. This amount is so small that it has little, if any, significance. Also, Table VII shows that Nos. 29 and 30 were gaining faster the

*This represents a three day gain, rather than a week.

last ten days and perhaps would have passed Nos. 31 and 32 had the experiment continued a few days longer.

The indications here seem to be that the only effect the arsenic had was to cut down the number of grasshoppers the chickens would eat and possibly cause some enteritis of the intestines.

It was thought that the chickens receiving a balanced ration such as the growing ration fed in this experiment might not eat as large a number of hoppers as those receiving only grain, which may be more typical of conditions on the average farm. Therefore, on July 10 another experiment was started similar to the one recorded in Table V, except that in this case the chickens received cracked grain instead of the growing ration.

These were Brahmas 5 weeks old and weighed as follows: No. 33 - 5.5 ounces; No. 34 - 4.0 ounces; No. 35 - 5.5 ounces and No. 46 - 4.4 ounces. The chickens receiving poisoned grasshoppers were fed all they would eat and the others approximately the same number. They were fed twice daily.

At the close of the experiment, (Sept. 1) these chickens also were killed and autopsied.

Table VIII gives the data on this experiment.

TABLE VIII.

DATA ON FEEDING GRASSHOPPERS AND GRAIN TO CHICKENS.

Chickens Nos. 33 and 34 eating poisoned hoppers						Chickens Nos. 35 and 36 eating unpoisoned hoppers	
Date	Species hopper	No. eaten	% Poisoned	Amount Arsenic in mgs.	Weight	No. eaten	Weight
7-10	M. bis.	8	87.6	3.5916	9.5 oz.	9	9.9 oz.
	" "	5	100			5	
7-11	" "	14	100	9.1704		14	
	M. biv.	7	94.6			5	
7-12	M. bis.	11	100	5.3218		18	
	M. biv.	3	90			4	
7-13	" "	6	94.6	4.2713		8	
7-14	" "	4	100	3.0100		7	
7-15	" "	4	94.6			10	
	" "	4	100	5.8575		4	
7-16	" "	7	88.2	7.8064		7	
	" "	5	84.0			6	
7-17	M. bis.	16	100	4.7865	11.2 oz.	15	11.4 oz.
7-18	" "	13	90	7.2620		15	
	M. biv.	5	100			5	
7-19	M. bis.	13	100	9.6073		15	
	M. biv.	8	95			9	
7-20	M. bis.	14	80	3.3499		13	
7-21	M. biv.	5	100	9.0300		10	
	" "	7	100			6	
7-22	" "	6	100	8.2775		9	
	" "	5	100			6	
7-23	" "	6	100	4.5150		7	
7-24	" "	7	94.6	8.5448		7	
	" "	5	94.6		13.1 oz.	7	13.2 oz.
7-25	" "	5	94.6	3.5617		8	
7-26	" "	8	100	12.0400		8	
	" "	8	100			8	
7-27	" "	9	100	6.7725		8	
7-28	" "	8	94.6	9.4570		9	
	" "	5	100			8	
7-29	" "	7	100	5.2675		8	
7-30	" "	7	100	5.2675		8	

TABLE VIII.

DATA ON FEEDING GRASSHOPPERS AND GRAIN TO CHICKENS (Cont'd)

Chickens Nos. 33 and 34 eating poisoned hoppers						Chickens Nos. 35 and 36 eating unpoisoned hoppers	
Date	Species hopper	No. eaten	% Poisoned	Amount Arsenic in mgs.	Weight	No. eaten	Weight
7-31	M. biv.	15	94.7	10.6892	15.1 oz.	13	16.4 oz.
8-1	" "	10	94.7	7.1262		12	
8-3	" "	8	94.6	5.6949		12	
8-4	" "	10	100	7.5250		13	
8-5	" "	15	95	10.7231		20	
8-6	" "	13	95	9.2934		14	
8-7	" "	18	95	12.8677		15	
8-8	" "	8	94.6	5.6949	17.6 oz.	21	18.8 oz.
8-9	" "	14	95			14	
	" "	5	95	13.5827		13	
8-10	" "	12	100	9.0300		13	
8-11	" "	16	100	12.0400		16	
8-12	" "	10	100	7.5250		16	
8-13	" "	20	94.7	14.2524		20	
8-14	" "	13	95	9.2934		20	
8-15	" "	14	100	10.5350	19.4 oz.	21	22.1 oz.
8-16	" "	14	96	10.1136		20	
8-17	" "	13	100	9.7825		20	
8-18	" "	18	95	12.8677		20	
8-19	" "	15	93.4	10.5425		20	
8-20	" "	15	100	11.2875		20	
8-21	" "	16	100	12.0400		20	
8-22	" "	14	95	10.0083	22.1 oz.	18	24.1 oz.
8-23	" "	14	100	10.5350		20	
8-25	" "	17	95	12.1529		20	
8-26	" "	20	100	15.0500		20	
8-27	" "	17	95	12.1529		20	
8-28	" "	24	100	18.0600		20	
8-29	" "	15	100	11.2875	24.9 oz.	20	26.7 oz.
8-30	" "	15	95	10.7231		22	
8-31	" "	19	100	14.2975		22	
9-1	" "	22	95	15.7272	26.1 oz.	20	28.8 oz.
					gain		gain
Total:		714		479.2687	16.6 oz.	859	18.9 oz.

Notes - In this experiment, the same as in the previous one, the chickens receiving poisoned grasshoppers (Nos. 33 and 34) were much slower in eating them after the first two days than those receiving unpoisoned grasshoppers (Nos. 35 and 36). Nos. 35 and 36 in nearly all cases ate their grasshoppers at once and apparently looked for more while Nos. 33 and 34 did not seem to be much interested in them. Again no symptoms of poisoning occurred at any time.

Notes of autopsy - No. 34 - tubules of kidneys appeared to be slightly enlarged and swollen.

No. 35 - slight edema of heart muscle.

No. 33 and 36 - normal.

Comments - The swollen tubules of the kidneys in No. 34 may have resulted from the arsenic. This again, however, is more likely to have been the result of the continued feeding of the arsenic rather than the amount received in any particular 3 to 4 day interval, as is usually the case under field conditions. Apparently the poison had little effect on the fowl.

Table IX was prepared by the same method as Table VI (page 90), showing the percentage of a dangerous dose the chickens received each week.

TABLE IX.

WEEKLY PERCENTAGE OF TOXIC DOSE CONSUMED BY CHICKENS

Chickens Nos. 33 and 34

	Amount of arsenic slightly toxic	Largest dose received any day	% Toxic dose	Factor of safety
1st week	31.9485	9.1704	28.70	3.5 to 1
2nd week	37.6656	9.6703	25.67	3.9 to 1
3rd week	44.0553	12.0400	27.33	3.7 to 1
4th week	50.7813	12.8677	25.34	3.9 to 1
5th week	59.1883	14.2524	24.08	4.2 to 1
6th week	65.2422	13.8677	19.72	5.1 to 1
7th week	74.3223	18.0600	24.30	4.1 to 1
8th week	83.7387	14.2975	17.07	5.9 to 1

Table IX, as compared with Table VI, shows that the greatest factor of safety for any particular weight in the chickens receiving only grain and grasshoppers was 5.9 to 1, as compared to 32.5 to 1 for those receiving a balanced ration in addition to the grasshoppers. Also, the smallest factor of safety in those receiving a balanced ration (6.3 to 1) is greater than the greatest factor of safety in those receiving only grain.

This indicates that chickens receiving a balanced ration are in much less danger of being poisoned from eating poisoned grasshoppers than those receiving only grain. It also indicates that under these conditions the chickens will

eat only approximately 29 per cent of what we are considering a slightly toxic dose at first, and thereafter a decreasing percentage.

Table X was prepared to show the weekly gain of chickens Nos. 33, 34, 35 and 36 fed only grain and grasshoppers.

TABLE X.

WEEKLY GAIN OF CHICKENS

	Gain, in ounces, Birds Nos. 33 and 34	Gain, in ounces, Birds Nos. 35 and 36
1st week	1.7	1.5
2nd week	1.9	1.8
3rd week	2.0	3.2
4th week	2.5	2.4
5th week	1.8	3.3
6th week	2.7	2.0
7th week	2.9	2.6
8th week*	1.2	2.1
Total gain	16.6	18.9

In the above experiment the chickens receiving the unpoisoned grasshoppers (Nos. 35 and 36) gained 2.3 ounces more than those receiving poisoned grasshoppers, while in the previous experiment where a balanced ration was fed there was a difference of 1.05 ounces in favor of the chickens receiving unpoisoned hoppers. In each case, the difference does not appear sufficiently large to be of importance.

*This represents a 3 day gain rather than a week.

However, it is a further indication of the fact that chickens receiving a balanced ration are less affected by poisoned grasshoppers than those receiving grain alone.

At the time Nos. 29 to 32 were started, which were baby chicks, Nos. 37 and 38, which were larger chickens, were also started to determine what effect the feeding of poisoned grasshoppers might have on different ages and sizes of chickens. Nos. 37 and 38 were White Leghorn chickens, and the weights were as follows: No. 37 - 8 ounces; No. 38 - 9 ounces.

The data on this experiment are shown in Table XI.

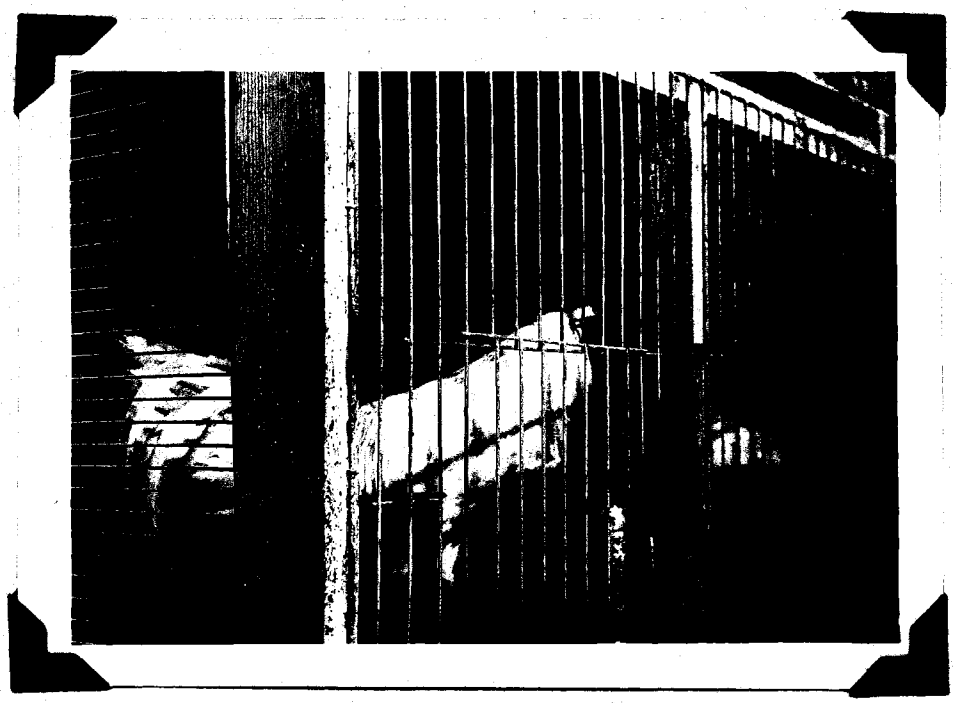

Fig. 13. Type of Cages Used in Feeding Adult Chickens.

TABLE XI.

DATA ON FEEDING GRASSHOPPERS AND GROWING RATION TO CHICKENS.

Chicken No. 37 eating poisoned hoppers							Chicken No. 38 eating unpoisoned hoppers	
Date	Species hopper	No. eaten	% Poisoned	Amount arsenic in mgs.	Weight		No. eaten	Weight
6-16	M. fem.	16	90	4.0378	8 oz.		16	9 oz.
6-17	M. bis.	14	85	5.8728			14	
	M. fem.	11	75				11	
6-18	" "	8	75	5.4678			8	
	" "	18	75				18	
6-19	M. bis.	19	90	5.1146			19	
6-20	M. fem.	8	94	10.5260			8	
	" "	9	95				11	
	M. biv.	8	100				8	
6-21	" "	17	95	12.1529			19	
6-22	" "	10	93	6.9982			10	
6-23	" "	3	100	2.2575	8.7 oz.		5	10.2 oz.
6-24	" "	3	100	2.2575			5	
6-25	" "	6	85	6.6596			6	
	" "	5	75				5	
6-26	" "	5	100	3.7625			7	
6-27	" "	2	100	1.5050			2	
6-28	" "	5	84	3.1605			5	
6-29	" "	5	84	3.1605			5	
6-30	" "	5	90	3.3863	11.2 oz.		5	11.6 oz.
7-1	M. bis.	7	89	1.8634			7	
7-2	" "	8	83	1.9860			10	
7-3	M. biv.	4	95	2.8595			4	
7-4	M. bis.	7	95	1.9890			7	
7-5	M. biv.	7	100	5.2675			7	
7-6	" "	7	94	4.9514			1	
7-7	" "	5	95	3.5744	14.4 oz.		0	15.4 oz.
7-8	" "	6	100	4.5150			6	
7-9	" "	7	95	5.0041			7	
7-10	" "	5	95	3.5744			5	
7-11	" "	7	89	4.6881			7	
7-12	" "	7	100	5.2675			7	

TABLE XI.

DATA ON FEEDING GRASSHOPPERS AND GROWING RATION TO CHICKENS (Cont'd).

Chicken No. 37 eating poisoned hoppers							Chicken No. 38 eating unpoisoned hoppers	
Date	Species hopper	No. eaten	% Poisoned	Amount arsenic in mgs.	Weight		No. eaten	Weight
7-13	M. biv.	6	90	4.0635			6	
7-14	" "	3	89	2.0092	17.5 oz.		5	15.8 oz.
7-15	" "	4	100	3.0100			5	
7-16	" "	5	100	3.7625			7	
7-17	" "	5	100	3.7625			6	
7-18	" "	4	94	2.8294			5	
7-19	" "	3	90	2.0318			6	
7-20	" "	6	100	4.5150			3	
7-21	" "	6	100	4.5150			8	
7-22	" "	6	100	4.5150	22.2 oz.		6	19.0 oz.
					gain			gain
Total		302		156.8735	14.2 oz.		310	10 oz.

Notes - No. 37, after the first two days, was much slower in eating grasshoppers than No. 38, excepting July 6th to 9th, inclusive. These four days No. 38 appeared to be quite ill and ate very little food of any kind. At all other times No. 38 ate the grasshoppers much more quickly than No. 37 and appeared to desire more. At no time did No. 37 show any indications of poisoning.

Notes of autopsy - No. 37 - slight ulceration of gizzard and duodenum, some enteritis of duodenum, kidneys slightly inflamed.

No. 38 - kidneys slightly inflamed, bones poorly developed.

Comments - Here appears further evidence that the feeding of poisoned grasshoppers over long periods of time results in ulceration of the digestive tract. Since No. 37 gained more weight during the experiment it also further indicates that so far as gain in body weight is concerned, this slight ulceration is not of importance. In this case, however, the evidence is not clear cut because of the fact that No. 38 was "off feed" for a period of 4 days.

As before, the following table was prepared to show how nearly No. 37 came to consuming a theoretical toxic dose of arsenic.

TABLE XII.

WEEKLY PERCENTAGE OF TOXIC DOSE CONSUMED BY CHICKENS

Chicken No. 37

	Amount of arsenic slightly toxic	Largest amt. consumed any day	% Toxic dose	Factor of safety
1st week	28.8684	13.1529	53.14	1.9 to 1
2nd week	29.2581	6.6596	22.76	4.4 to 1
3rd week	37.6656	5.2675	13.98	7.2 to 1
4th week	48.4272	5.2675	10.88	9.2 to 1
5th week	58.8525	4.5130	7.67	13.0 to 1
6th week	73.9860	4.5150	6.10	16.4 to 1

Table XII shows No. 37 to have come the nearest to receiving a toxic dose of any of the chickens fed on poisoned grasshoppers. On June 21 he consumed 53.14 per cent of a slightly toxic dose. Here, also, is an indication that older chickens are more likely to eat a sufficient number of poisoned grasshoppers to receive a toxic dose of arsenic than are baby chicks. Again we see the factor of safety increasing steadily after the first few days. Owing to the illness of No. 38, the difference in the amount of weight gained is of small significance.

Chickens Nos. 39 and 40 were fed grain only, with poisoned and unpoisoned grasshoppers. Table XIII gives the data on this experiment.

TABLE XIII.

DATA ON FEEDING GRASSHOPPERS AND GRAIN TO CHICKENS.

Chicken No. 39 eating hoppers poisoned with white arsenic and bran						Chicken No. 40 eating unpoisoned hoppers	
Date	Species hopper	No. eaten	% Poisoned	Amount arsenic, in mgs.	Weight	No. eaten	Weight
7-2	M. biv.	12	95	8.5785	12.2 oz.	17	12.8 oz.
7-3	" "	10	95	7.1488		10	
7-4	" "	15	95	10.7231		15	
7-5	" "	9	95	6.5339		9	
7-6	" "	8	94	5.6588		10	
7-7	" "	7	100	5.2675		9	
7-8	" "	7	100	5.2675	11.2 oz.	8	13.3 oz.
7-9	" "	10	94	7.0735		10	
7-10	" "	9	100	6.7725		9	
7-11	" "	10	100	7.5250		10	
7-12	" "	11	90	7.4475		10	
7-13	" "	10	95	7.1488		10	
7-14	" "	10	100	7.5250		10	
7-15	" "	10	94	7.0735	11.5 oz.	8	15.6 oz.
7-16	" "	9	100	6.7725		10	
7-17	" "	10	100	7.5250		10	
7-18	" "	10	100	7.5250		10	
7-19	" "	10	90	6.7725		10	
7-20	" "	10	80	6.0200		4	
7-21	" "	10	100	7.5250		14	
7-22	" "	10	100	7.5250	12.8 oz.	10	31.0 oz.
					gain		gain
Total		207		149.3089	.6 oz.	213	8.2 oz.

Notes - During this experiment, a special effort was made to get No. 39 to eat as many poisoned grasshoppers as possible, and as before, feed the check bird (No. 40) approximately the same number. In order to accomplish these results, only very small portions of grain were fed the birds. Each bird appeared perfectly normal throughout the experiment.

Notes of autopsy - No. 39 - moderate enteritis of duodenum. Musculature somewhat translucent.

No. 40 - slight ulceration of the gizzard, mild enteritis of duodenum.

Commente - In this case we find ulceration of the gizzard of the check bird and none in the bird feeding upon poisoned grasshoppers. This would seem to indicate that the small ulcers that have been noticed in several of the birds were due to another cause than the arsenic, possibly to the spurs on the tibia of the grasshoppers they had eaten. In this case we also find both birds having enteritis of the duodenum. Another interesting fact is that the bird having ulcers of the gizzard gained more weight during the experiment than the other bird.

In this case, No. 40 has a decided advantage in weight gained during the experiment, which in itself indicates the arsenic may have been responsible since neither bird showed any signs of illness, as in the previous experiment.

TABLE XIV

WEEKLY PERCENTAGE OF TOXIC DOSE CONSUMED BY CHICKENS

Chickens Nos. 39 and 40

	Amount of arsenic slightly toxic	Largest Amt. arsenic consumed any day	% Toxic dose	Factor of safety
1st week	41.0286	10.7231	26.13	3.8 to 1
2nd week	37.6656	7.0735	18.78	5.3 to 1
3rd week	38.6745	7.5205	19.46	5.1 to 1
4th week	43.0464	7.5205	17.48	5.7 to 1

During the first few days, the amount most nearly approaching the theoretical toxic dose of arsenic was eaten. In this case 26.13 per cent of such a dose was the nearest approach. This experiment differs from the previous one in that this time the chicken on a balanced ration came nearer receiving a toxic dose than the one having grain only, in addition to grasshoppers. In each case, the older chickens consumed more nearly a toxic dose of arsenic. As usual, the factor of safety increased steadily throughout the experiment.

In all the experiments already described the chickens receiving the poisoned grasshoppers also had access to other food. While it appears improbable, still it is possible that the condition might arise that the chickens had nothing to feed on other than poisoned hoppers. Consequently it was desired to learn what the results might be under these

circumstances. It was decided to run a 10 day test in which the chickens would receive nothing but grasshoppers and water. Table XV gives the data on this experiment. White Leghorns were used.

TABLE XV

DATA ON FEEDING GRASSHOPPERS ONLY TO CHICKENS.

Chicken No. 41 eating poisoned grasshoppers						Chicken No. 42 eating unpoisoned grasshoppers	
Date	Species hopper	No. eaten	% Poisoned	Amount arsenic, in mgs.	Weight	No. eaten	Weight
7-28	M. biv.	40	94.7	28.5047	23 oz.	28	25 oz.
7-29	" "	42	100	31.6050		51	
7-30	" "	45	100	33.8625		49	
7-31	" "	32	100	24.0800		55	
8-1	" "	49	94.7	34.9183		59	
8-2	" "	37	100	27.8425		63	
8-3	" "	41	94.7	29.2173		49	
8-4	" "	50	100	37.7250		67	
8-5	" "	50	95	35.7694		83	
8-6	" "	38	95	27.1653	22.5 oz. loss .5 oz.	57	26 oz. gain 1 oz.
Total		424		310.5900		561	

Notes - Again in this case approximately the same number of grasshoppers was fed each bird. On Aug. 5, through error No. 42 was fed more grasshoppers than was planned. Again, in this experiment the chicken feeding upon unpoisoned grasshoppers ate them much more rapidly, and apparently would have eaten more if they had been provided. After the third day, No. 41 had a light case of diarrhoea and did not feed

as rapidly and greedily as would be expected of a chicken on such a diet, but at no time was any droopiness or other symptoms of poisoning exhibited.

Notes of autopsy - No. 41 - slight enteritis of the duodenum, kidneys slightly hyperemic.

No. 42 - moderate enteritis of the duodenum, heart very flabby.

Comments - Here we have an indication that the enteritis that has been appearing so frequently may not be due to the arsenic contained in the grasshoppers but to some other cause; also, that the arsenic may affect the kidneys, which seems plausible since the kidneys are so active in ridding the body of the arsenic. This experiment also is further proof that chickens do not feed as heavily upon poisoned grasshoppers as upon unpoisoned grasshoppers.

In this case No. 41 lost one-half an ounce during the 10 day period, while No. 42 gained one ounce, making a difference of one and one-half ounces in favor of the chicken receiving unpoisoned grasshoppers.

Since 3.363 mg. of arsenic is considered to constitute a slightly toxic dose, 77.3490 mg. is the amount that would be expected to be toxic to this bird. But throughout the 10 days, 37.7250 mg. was the largest amount consumed any one day, which is 48.77 per cent of a toxic dose. Therefore,

even under as severe conditions as these the chickens consumed less than 50 per cent of an amount that is slightly toxic.

All of the above experiments were conducted during the summer of 1930 and all the poisoned grasshoppers fed were poisoned with a bran mash containing 4 pounds of white arsenic to 96 pounds of bran.

In recent years another arsenical, sodium arsenite, Na_2HAsO_3, has been gaining in popularity as the poisoning agent to be used in bran for combating grasshoppers. This arsenical has advantages over white arsenic or Paris green, which previously had been used so extensively.

According to Corkins (10) its advantages are as follows: "Its entire solubility in cold water means that all particles of water carry exactly the same amount of poison, and that every flake of bran which is moistened is also poisoned. Therefore, from the standpoint of mixing, it is as nearly 'fool proof' as any chemical can be." The cost is less. It reduces the labor of mixing due to the fact that no preliminary mixing of the bran and a powder is necessary, as is the case when using white arsenic or Paris green. There is no poisonous dust floating through the air at the mixers; thus reducing the danger of poisoning the persons doing the mixing. Due to its solubility, it is more toxic than white arsenic.

On account of these advantages, several state entomologists are now recommending the use of sodium arsenite; therefore it was considered advisable to test this form of arsenic, as well as white arsenic.

Corkins recommended sodium arsenite (liquid) containing 8 pounds of arsenic per gallon be used at the rate of 1 pint per 100 pounds of bran. However, later developments indicate it to be more desirable to use it at the rate of 1 quart per 100 pounds of bran; therefore that was the amount used in the following experiments, except that only 98 pounds of bran were used per quart of arsenic in order to make the percentages easier to figure and also to make the experimental conditions still more severe than field conditions.

The sodium arsenite used in these experiments was prepared by the Agricultural Chemistry Department of Oklahoma A. and M. College, as follows: 111 grams of sodium hydroxide were dissolved in approximately 400 cc. of water. While the solution was still hot, 1 pound of chemically pure arsenic trioxide (As_2O_3) was added with stirring, until all was dissolved. When cool, water was added to the solution to bring its volume to one pint. Thus, it is seen that the solution contains 8 pounds As_2O_3 per gallon.

In preparing the poison bran particular care was taken to see that it was evenly and thoroughly mixed. The

arsenite was first diluted with approximately one half the amount of water required, placed in a knapsack spray and sprayed as a fine misty spray over the bran as it was stirred. By this method each flake of bran was as evenly moistened as seemed possible.

Again in this instance no attrahents of any kind were added as it was thought perhaps the lack of an attrahent might to some extent offset the fact that the grasshoppers feeding on this bran were to be confined in small cages with no other food available.

It will be noticed that in this case 2 pounds white arsenic (As_2O_3) in the form of sodium arsenite are used, while 4 pounds of As_2O_3 in the less soluble form were used in the previous mixture.

As shown on page 37 of this paper, Van Zyl found As_2O_3 in its soluble form as sodium arsenite just twice as toxic to chickens as As_2O_3 in the form of white arsenic. His findings were accepted in this case and no experimental work carried on to determine the toxicity of this mixture to chickens.

It was also desired to feed to chickens some hoppers containing a greater amount of arsenic than the amount they would eat normally in feeding upon grasshopper bait. In order to accomplish this, the following method was used: The sodium

arsenite, prepared as above described, was diluted in water at the rate of 1 cc. of this solution to 25 cc. of water.

This diluted solution was measured and injected into the body cavity of the grasshopper by means of a hypodermic needle at the rate of .05 cc. to each grasshopper.

Since there are 473.1746 cc. per pint and 354.59 gms. per pound, 453.59 ÷ 473.1746 or .95861 = the number of gms. per cc. of the original solution. Since 1 cc. of this solution was diluted to 25 cc, 1/25 of .95861 or .0383444 = the number of gms. per cc. of the diluted solution. Then 5/100 of .0383444 or .0019172 = number of gms. each injected grasshopper contained. This, of course, is 1.9172 mg. Therefore, this number multiplied by the number of grasshoppers the birds ate gives the amount of arsenic the bird thus obtained.

The work carried on during the summer of 1931 differed from that of the previous summer in the following respects. First, grasshoppers poisoned with sodium arsenite and bran, and grasshoppers injected with sodium arsenite were fed in addition to those poisoned with white arsenic and bran. Second, the funds this year for continuing the experiment were quite low; therefore, the birds were not killed at the end of each experiment for the autopsy but were traded for others with which to conduct further experiments and only the

birds that died were autopsied. Third, during these experiments both the experimental and check chickens were fed all the grasshoppers they would eat rather than feeding the checks only the approximate number that the experimental birds ate.

Otherwise, the work was carried on as during the previous summer.

In the next experiment, 2 Rhode Island Red chickens, approximately one year old, were used. For 10 days No. 43 was fed grasshoppers poisoned with sodium arsenite and bran, and No. 44 unpoisoned grasshoppers.

Fig. 14. Chicken No. 43, Which Made a Large Gain on Poisoned Grasshopper Diet.

Table XVI gives the results of this experiment.

TABLE XVI.

DATA ON FEEDING GRASSHOPPERS AND GROWING RATION TO CHICKENS.

Date	Hour	Bird No. 43 - fed hoppers poisoned with white arsenic and bran. Wt. 4 lb. 6 oz. No. eaten	% Poisoned	Amount Arsenic, in mgs.	Bird No. 44 - fed unpoisoned hoppers. Wt. 4 lb. 4 oz. No. eaten
7-2	8 AM	10	98	3.6872	10
	5 PM	10	98	3.6872	10
7-3	8 AM	19	98	7.0058	14
	5 PM	26	98	9.5868	20
7-4	8 AM	23	100	8.6537	24
	5 PM	21	100	7.9012	27
7-5	8 AM	30	100	11.2875	30
	5 PM	26	100	9.7825	41
7-6	8 AM	25	100	9.4062	43
	5 PM	28	100	10.5350	25
7-7	8 AM	15	100	5.6437	23
	5 PM	15	100	5.6437	42
7-8	8 AM	17	94.7	6.0572	45
	5 PM	12	94.7	4.2757	30
7-9	8 AM	10	94.7	3.5631	30
	5 PM	20	94.7	7.1263	30
7-10	8 AM	30	100	11.2875	50
	5 PM	25	100	9.4062	40
7-11	8 AM	25	87.7	8.4293	35
	5 PM	23	87.7	7.5893	25
Total:		410		150.5540	594

Weight 7-11; No. 43 - 5 lb. 8 oz.
No. 44 - 4 lb. 13 oz.

At the end of the 10 day period, the feeding was reversed and for the following 10 days, No. 44 received poisoned grasshoppers and No. 43 the unpoisoned grasshoppers. The results of this feeding test are shown in Table XVII.

TABLE XVII.

DATA ON FEEDING GRASSHOPPERS AND GROWING RATION TO CHICKENS.

During the 10 days previous to this experiment, No. 43 was fed poisoned grasshoppers and No. 44 unpoisoned grasshoppers. See Table XVI.

		Bird No. 44 - fed hoppers poisoned with sodium arsenite and bran. Wt. 4 lb. 13 oz.			Bird No. 43 fed unpoisoned hoppers. Wt. 5 lb. 8 oz.
Date	Hour	No. eaten	% Poisoned	Amount arsenic, in mgs.	No. eaten
7-12	8 AM	29	90.4	9.8638	20
	5 PM	6	90.4	2.0408	30
7-13	8 AM	10	88.8	3.2658	31
	5 PM	14	88.8	4.5732	50
7-14	8 AM	20	97.2	7.3143	49
	5 PM	40	97.2	14.6286	40
7-15	8 AM	47	86.8	15.3495	20
	5 PM	9	86.8	2.9393	40
7-16	8 AM	4	91.8	1.3816	50
	5 PM	3	91.8	1.0362	52
7-17	8 AM	4	84.6	1.2732	40
	5 PM	5	84.6	1.5915	50
7-18	8 AM	5	84.6	1.5915	30
	5 PM	3	84.6	0.9549	26
7-19	8 AM	26	84.6	8.2760	50
	5 PM	2	84.6	0.6366	46
7-20	8 AM	8	89.0	2.0092	21
	5 PM	5	89.0	1.6743	55
7-21	8 AM	7	89.0	2.3440	18
	5 PM	2	75.2	0.5659	25
Total		247		83.3092	743

Weights 7-21; No. 44 - 4 lb. 9 oz.
No. 43 - 5 lb. 8 oz.

Notes - As before stated, most of the chickens used in this experiment were taken from the flock of the Poultry Department of Oklahoma A. and M. College. However, birds of this type were not available in the college flock at this time and therefore the birds were secured from a farm flock near Stillwater. Their food previous to this time consisted mostly of such waste materials as are found around most farm yards.

It was evident almost from the beginning that No. 43 was a heavier feeder than No. 44. Throughout the 20 day period, more of the mash was consumed by No. 43 than by No. 44. During the first 10 days, No. 43 drank approximately twice as much water as No. 44,but during the second 10 day period, No. 43 drank more water than No. 44 a part of the time. The rest of the time they drank approximately the same amount. The faeces of No. 43 contained much more moisture than No. 44 throughout the first ten days but at no time could any indication of diarrhoea be detected. During the second ten days the faeces of each contained about the same amount of moisture.

Comments - In previous and in following experiments the difference in consumption of water was small but in these experiments the feeding of poisoned grasshoppers appeared to increase consumption of water very distinctly, as well as

moisture content of faeces.

During the first 10 day period No. 43 gained 18 ounces and No. 44 gained 9 ounces, a difference of 9 ounces in favor of the chicken eating poisoned grasshoppers. However, when the feeding was reversed, No. 43 maintained her weight and No. 44 lost 4 ounces, a difference of 4 ounces in favor of the chicken eating unpoisoned grasshoppers. The writer, however, after observing these birds closely for 20 days, feels that these differences were due more to the variation in the appetites of the two birds than to the arsenic they received in the grasshoppers.

Since we are considering 3.363 mg. per ounce to be a slightly toxic dose, this amount x 70 (the weight in ounces of No. 43 at the beginning of the experiment) or 235.4100 mg. should constitute a slightly toxic dose. This, however, applies to white arsenic instead of sodium arsenite. For reasons previously given, sodium arsenite is considered twice as toxic and therefore one-half of 235.4100 or 117.7050 mg. of this material should constitute a slightly toxic dose. Table XVI, however, shows that on July 5 No. 43 consumed the greatest amount of sodium arsenite and on this day ate 11.2675 mg. This is only 17.90 per cent of a toxic dose, indicating a factor of safety in this case of 5.59 to 1.

In the case of No. 44, the toxic dose is figured to

be 122.7495 mgs. Table XVII shows the greatest amount consumed in any one day to have been on July 14 when 21.9429 mgs. were consumed. This is 17.88 per cent of a toxic dose and a factor of safety of 5.59 to 1. Here the factor of safety was the same in each case.

No. 43 apparently did not object to poisoned grasshoppers as strongly as No. 44, as can be seen by comparing Tables XVI and XVII as to the number of grasshoppers eaten. No. 43 ate 410 poisoned grasshoppers as compared to 594 unpoisoned grasshoppers for No. 44. In other words, 43 ate 69.02 per cent as many grasshoppers as No. 44. However, when the feeding was reversed, No. 44 ate only 247 grasshoppers as compared to 743 for No. 43, or only 33.24 per cent of the number eaten by No. 43. This indicates considerable variation in individual chickens with regard to appetite for grasshoppers, or resistance, tolerance or taste for poisoned grasshoppers. Here again we have pronounced proof that chickens refuse to eat as many poisoned as unpoisoned grasshoppers.

Table XVII shows that No. 44 ate 107 poisoned grasshoppers containing 37.2924 mgs. sodium arsenite in three feedings July 14 and 15. This apparently caused her to desist from eating so many thereafter, for 81 more were all that were eaten during the next 8½ days. After 8 A. M. the 15th, 9 was the greatest number eaten at any one feeding for

3½ days. At the end of this period 26 were eaten at one feeding. Thereafter 7 was the greatest number consumed at one feeding until the close of the experiment 2½ days later.

The indications here are that when a large number of poisoned grasshoppers are eaten, something causes the chickens to eat a smaller number thereafter for a few days at least. It seems probable that the arsenic contained in the bodies of the grasshoppers is responsible for such actions.

For the next experiment, the same type of chickens was used as in the previous test; namely, two Rhode Island Red hens, which were secured from a farm near Stillwater. In this experiment, No. 45 was fed grasshoppers injected, as previously described, with sodium arsenite and No. 46 unpoisoned grasshoppers. Each was fed all she would eat twice a day. Table XVIII gives the data on this experiment.

TABLE XVIII.

DATA ON FEEDING GRASSHOPPERS AND GROWING RATION TO CHICKENS.

Date	Hour	Bird No. 45 - fed hoppers injected with sodium arsenite. Wt. 3 lb. 2 oz. No. hoppers eaten	Amount of arsenic, in mgs.	Bird No. 46 - fed unpoisoned hoppers. Wt. 2 lb. 12 oz. No. hoppers eaten
8-3	8 AM	15	28.7580	29
	5 PM	4	7.6688	19
8-4	8 AM	2	3.8344	20
	5 PM	5	9.5860	29
8-5	8 AM	0		46
	5 PM	0		30
8-6	8 AM	2	3.8344	28
	5 PM	5	9.5860	18
8-7	8 AM	1	1.9172	30
	5 PM	4	7.6688	29
8-8	8 AM	4	7.6688	27
	5 PM	0		26
8-9	8 AM	0		15
	5 PM	2	3.8344	11
8-10	8 AM	3	5.7516	20
	5 PM	3	5.7516	43
8-11	8 AM	0		34
	5 PM	3	5.7516	35
8-12	8 AM	0		27
	5 PM	0		18
8-13	8 AM	0		23
	5 PM	0		25
Total:		53	101.6115	582

Weights 8-13, No. 45 - 2 lbs. 15 oz.
No. 46 - 3 lbs. 1 oz.

Notes - The second day of the experiment No. 45 plainly appeared to be suffering from arsenical poisoning. She was quite droopy, sitting around most of the time, very frequently with eyes closed. Diarrhoea pronounced. Faeces greenish in color, watery and stringy. By the sixth day, she was distinctly improved and thereafter seemed to be quite normal. Frequently during the last six days, she would pick the grasshoppers up and drop them again instead of swallowing them.

Comments - For the first time during the experiments, what appears to be definite symptoms of arsenical poisoning appear. Also it appears in a chicken of 3 pounds 2 ounces in weight, in which the theoretical toxic dose is 84.0750 mgs. The largest amount received in one day was the first day when 36.4268 mgs. of arsenic as sodium arsenite were received. This is only 43.32 per cent of the theoretical toxic dose. This seems to indicate either that sodium arsenite is more toxic in a liquid form than when administered in a powdered form as was done by Van Zyl (54) or that this bird was more susceptible to arsenic than those Van Zyl experimented with.

Here also is still more definite proof that chickens will eat a greater number of unpoisoned hoppers than of poisoned ones. This experiment also indicates that the more

arsenic the grasshoppers contain, the fewer grasshoppers the chickens will eat.

In this case, No. 45 ate only 53 grasshoppers in a period of 10 days while No. 46 ate 582. In other words, only 9.10 per cent as many grasshoppers were eaten when as heavily poisoned as these were.

For the next experiment, a different variety of chickens was selected. They were Buff Orpingtons weighing from 1 pound 10 ounces to 1 pound 15 ounces. They were fed as indicated in Table XIX.

TABLE XIX.

DATA ON FEEDING GRASSHOPPERS ONLY TO CHICKENS.

	Bird No. 47 -fed hoppers poisoned with white arsenic and bran Wt. 1 lb. 14 oz.			Bird No. 48 - fed hoppers poisoned with sodium arsenite and bran Wt. 1 lb. 15 oz.			Bird No. 49 - fed hoppers injected with sodium arsenite. Wt. 1 lb. 10 oz.			Bird No. 50 - fed unpoisoned hoppers Wt. 1 lb. 10 oz.
Date	No. eaten	% Poisoned	Amount arsenic in mgs.	No. eaten	% Poisoned	Amount arsenic in mgs.	No. eaten	Amount arsenic in mgs.		No. eaten
8-17										
8 AM:	5	95.2	3.5819	5	95.2	1.7909	5	2.5860		5
5 PM:	7	95.2	5.0147	3	95.2	1.0746	7	13.4204		7
8-18										
8 AM:	7	95.2	5.0147	4	95.2	1.4328	0			7
5 PM:	6	90.1	4.0680	1	95.2	0.3582	0			7
8-19										
8 AM:	5	90.1	3.3900	2	95.2	0.7164	0			7
5 PM:	0	90.1		1	95.2	0.3582	0			7
8-20										
8 AM:	4	90.1	2.7120	0			0			7
5 PM:	3	90.1	1.8560	0			2	3.8344		7
8-21										
8 AM:	7	90.1	4.7460	0	92.3		3	5.7516		7
5 PM:	8	91.2	6.0922	2	92.3	0.6946	2	3.8344		6
8-22										
8 AM:	8	91.2	6.0922	6	92.3	2.0837	0			8
5 PM:	9	91.2	6.1765	2	92.3	0.6946	0			9
8-23										
8 AM:	9	91.2	6.1765	6	92.3	2.0837	1	1.9172		11
5 PM:	12	91.2	8.3257	6	92.3	2.0837	1	1.9172		13
8-24										
8 AM:	14	91.2	9.6079	8	92.3	2.7782	0			14
5 PM:	16	91.2	10.9804	7	88.9	2.3414	0			16
8-25										
8 AM:	16	91.2	10.9804	8	88.9	2.6759	0			18
5 PM:	16	91.2	10.9804	8	88.9	2.6759	0			18
8-26										
8 AM:	16	91.2	10.9804	4	88.9	1.3379	0			15
5 PM:	4	91.2	2.7451	6	88.9	2.0069	0			20
Total:	171		236.3165	79		37.1876	21	40.2612		209

Weight, 8-26; No. 47 - 1 lb. 7 oz.; No. 48 - 1 lb. 9 oz;
No. 49 - 1 lb. 6 oz; No. 50 - 1 lb. 8 oz.

Notes - No. 49 was the only bird to show any indications of poisoning. The others appeared quite normal and even on a diet of grasshoppers only did not seem to be unusually hungry. Even the check, No. 50, ate an exceedingly small number as compared to other chickens of a similar weight that have been used in these experiments.

On the morning of the 18th, No. 49 appeared to be very sickly. Most of the time she stood with head drooping quite low and eyes closed. Diarrhoea pronounced. Faeces watery and slimy, greenish to blackish in color. Eyes and nose inflamed. Slimy secretions dripping from mouth.

Aug. 19, 20, very little change in condition.

Aug. 21. Appeared to be in better condition. Eyes, though still inflamed, were kept open. Acted somewhat hungry and ate 3 grasshoppers in the morning and 2 more in the afternoon.

Aug. 22 - Condition worse, symptoms as above.

Aug. 23 - Ate 2 more grasshoppers, 1 in the morning and 1 in the afternoon. Became weaker steadily from the 23rd on and was found dead at 8 A. M. Aug. 26th.

Notes of autopsy - General condition very poor. Alimentary tract entirely empty. Kidneys inflamed and congested. Mesentery congested. Muscle tone of gizzard poor, lining of gizzrd, stomach and intestines showed severe

enteritis. Many symptoms of starvation.

Comments - The theoretical toxic dose of sodium arsenite for No. 49 is 43.7190 mg. The greatest amount received in any one day was Aug. 17th when 23.0064 mg. were eaten. This is only 52.64 per cent of the theoretical toxic dose and yet resulted in a very severe case of poisoning. The total amount of sodium arsenite received was 36.4268 mg, which is only 83.18 per cent of the theoretical toxic dose, but the results were fatal. This is further indication that in this form sodium arsenite is more toxic than previous experiments had indicated. From the standpoint of our problem, however, neither the poisoning of No. 49 nor 45 indicate any danger of poisoning under field conditions as the conditions here were much more severe than would ever occur in the poisoning of grasshoppers in the field.

It appears that the arsenic consumed by No. 47 had less effect than the pangs of hunger, for the number of grasshoppers consumed daily increased throughout the experiment, though irregularly. The total number of grasshoppers eaten (171) was 81.82 per cent of the total number (209) eaten by the check bird.

The greatest amount of arsenic consumed was the 9th day of the experiment, Aug. 25 when 21.9608 mgs. were eaten. This is 21.77 per cent of the theoretical toxic dose

as indicated by experiments recorded earlier in this paper.

No. 48 appeared to be distinctly more affected than No. 47 the first few days and on the fourth day entirely refused to eat the grasshoppers. Beginning the fifth day, however, the number eaten increased to the end of the experiment. Again in this case the greatest amount of arsenic was consumed the 9th day when 5.3518 mgs. in the form of sodium arsenite were eaten. This is 10.27 per cent of the theoretical toxic dose. In this case, the total number of grasshoppers eaten was 10.05 per cent of the number eaten by the check. This indicates that the arsenic contained in grasshoppers poisoned on sodium arsenite and bran reduces the number of grasshoppers the chickens will eat a great deal more than the arsenic contained in grasshoppers poisoned on white arsenic and bran. This, in turn, indicates that the sodium arsenite even in the smaller quantities is more toxic than the larger amounts of white arsenic. The experiments with Chickens Nos. 45 and 49 also gave this indication.

The final experiment discussed in the experiments with chickens consisted of feeding 2 White Leghorn chickens as indicated in Table XX. No. 51 was a pullet and No. 52 a cockerel.

TABLE XX.

DATA ON FEEDING GRASSHOPPERS ONLY TO CHICKENS.

		Bird No. 51 - fed hoppers poisoned with sodium arsenite and bran. Wt. 1 lb. 10 oz.			Bird No. 52 - fed unpoisoned hoppers. Wt. 1 lb. 9 oz.
Date	Hour	No. eaten	% Poisoned	Amount Arsenic, in mgs.	No. eaten
7-15	5 PM	39	90.4	9.8638	25
7-16	8 AM	15	90.4	5.1019	11
	5 PM	3	86.8	0.9796	30
7-17	8 AM	13	86.8	4.2456	30
	5 PM	21	86.8	6.8583	38
7-18	8 AM	26	97.2	9.5086	40
	5 PM	19	97.2	6.9486	40
7-19	8 AM	20	97.2	7.3143	48
	5 PM	21	91.2	7.2059	61
7-20	8 AM	16	91.2	5.4902	60
	5 PM	8	91.2	2.7451	45
7-21	8 AM	24	84.6	7.6584	54
	5 PM	13	84.6	4.1380	65
7-22	8 AM	21	84.6	6.6845	60
	5 PM	21	84.6	6.6845	75
7-23	8 AM	8	100.0	3.0100	70
	5 PM	12	89.0	4.0183	60
7-24	8 AM	6	75.2	1.6976	50
	5 PM	11	75.2	3.1123	50
7-25	8 AM	7	75.2	1.9806	60
		314		105.2271	972
Beginning 7-26, No. 51 was fed unpoisoned hoppers and No. 52 poisoned hoppers.					
7-26	8 AM	14	75.2	15.8446	56
	5 PM	24	75.2	1.1318	4
7-27	8 AM	20	75.2	1.1318	4
	5 PM	60			0
7-28	8 AM	60			0
Total		176		18.1082	64

Weights 7-25, No. 51 - 1 lb. 7 oz.
No. 52 - 1 lb. 13 oz.

Notes - No. 51 very wild when experiment was first started July 16. Faeces contain much moisture though the color is normal. Has a slight attack of diarrhoea.

July 17 and 18 - not much change.

July 19 - Some improvement but faeces of each contain distinctly more than the normal amount of moisture.

No. 51 is frantically hungry, rushes to door of cage when it is approached and picks madly at hands of the person feeding, also tries to get out to get to some grain visible from cage.

July 23 - No. 51 now eats all legs from hoppers, before eating body proper. This continues to July 25.

No. 52, as has been the case with most of the chickens in this experiment, wastes a large percentage of the hind legs.

July 26 - No. 51 still eating legs off hoppers, and only few hoppers.

July 27 - No. 51 now eats entire hopper without pulling legs off.

No. 52 has distinct attack of diarrhoea and entirely refuses to eat any grasshoppers.

July 28 - no change in No. 52.

Comments - The greatest amount of arsenic consumed by No. 51 was July 18 when 16.4572 mgs. was consumed. This is

37.58 per cent of the theoretical toxic dose and symptoms of poisoning occurred, which again indicates that the theoretical amount is too high. While eating poisoned grasshoppers, No. 51 ate 314 as compared to the 972 unpoisoned grasshoppers eaten by No. 52. In other words, No. 51 ate 32.30 per cent as many as eaten by the check.

In the writer's opinion, the behavior of No. 51 gave more information on the question in view than any other bird in all the experiments. In the first place, she showed that even though she was frantically hungry she would eat only a few of the poisoned grasshoppers. She indicated very strongly that she recognized the fact that too many grasshoppers made her ill. Further indications were that her great hunger kept her picking at the grasshoppers even though she knew they were injurious and thus learned that the legs of the grasshoppers would help to satisfy her hunger without having the ill effects that the bodies had, for later in the experiment she ate the legs off practically every hopper placed before her.

Most of the chickens in this experiment, particularly those feeding on unpoisoned grasshoppers, usually picked at the grasshoppers a few times before swallowing them and during this process the hind legs became detached and were discarded. It seemed that the spurs and spines of the hind tibia made them undesirable. But in this case, No. 51

considered them the most desirable part of the grasshopper despite the spurs and spines.

At 8 A. M., July 23, 70 grasshoppers were placed in the cage of No. 52 and 27 in the cage of No. 51. Thirty minutes later, the remains of the grasshoppers were gathered from each cage and photographed, (see fig. 18). The observation shows that a large number of the hind legs were left by No. 52, but that the bodies of every one of the 70 grasshoppers had been eaten. On the other hand, No. 51 had not left a single hind leg and very few legs of any kind. She had, however, left at least the greater portions of the bodies of 16 hoppers. In the opinion of the writer, this indicates about as clearly as anything possibly could, that No. 51 refused the bodies of the grasshoppers because she recognized that they were injurious to her.

On July 26th, when she began receiving unpoisoned grasshoppers, she still ate the hind legs off first and few bodies, and apparently in three feedings recognized the fact that they were no longer injurious, for at both the 4th and 5th feedings she ate the entire bodies of 60 grasshoppers. No. 52, on the other hand, after eating 56 poisoned grasshoppers at the first feeding dropped to 4 for the next two feedings and ate none at all the next two feedings.

Fig. 15. Chicken No. 51.

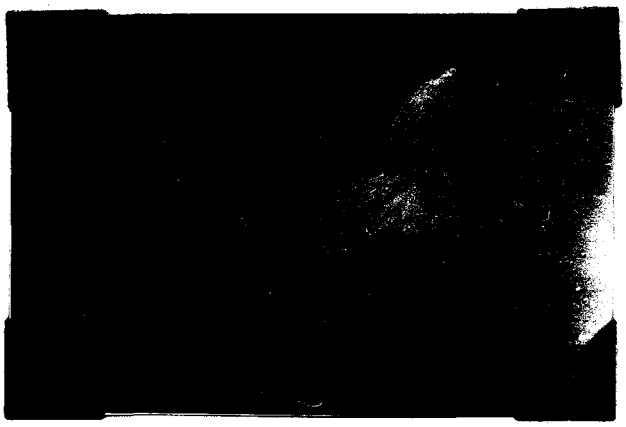

Fig. 16. Chicken No. 52.

Fig. 17. At Left, Remains of Grasshoppers Fed No. 52;
At Right, Remains of Grasshoppers Fed No. 51.

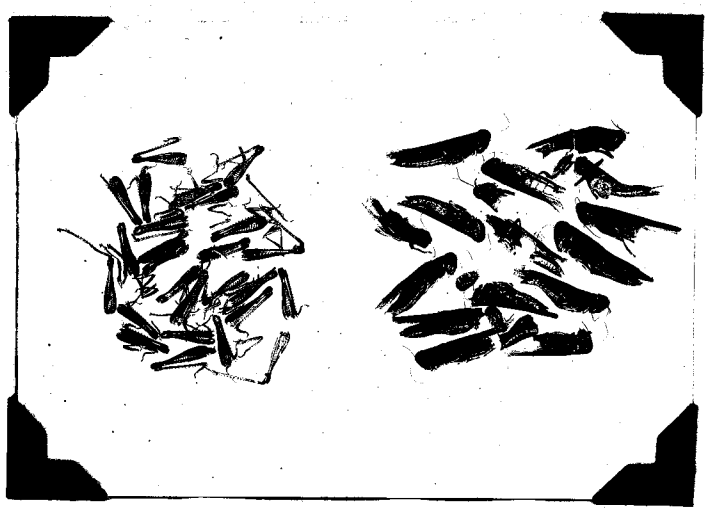

Fig. 18. A More Detailed View of Grasshopper Parts Left by No. 52 and No. 51.

(1) Discussion. The outstanding fact seen in this series of experiments is that in spite of the fact that the tests were made as severe as possible, a great deal more severe than could occur under field conditions, not a single chicken died from eating grasshoppers that had been killed by eating arsenic. The only one that died was one fed on grasshoppers that had been injected with large amounts of sodium arsenite, as compared to the amounts obtained when feeding on poisoned bran, and all other food withheld for a period of 10 days.

These tests were more severe than field conditions for any or all of the following reasons:

1. In some cases all other forms of food were

withheld, while under field conditions, at least small amounts of other food would always be available at the time of year grasshoppers are poisoned. Under these conditions it seems probable that they would eat more grasshoppers and thus obtain more arsenic than under field conditions.

2. The fact that no other food was available forced the chickens to consume the arsenic at all times when the crop was empty, under which conditions the injury is said to be more severe than when the crop is partially filled.

3. Some of these experiments extended over longer periods of time than under field conditions. One experiment extended through 66 days and all of them at least 10 days. Under field conditions large numbers of poisoned grasshoppers usually would not be available excepting a few days at a time.

4. Under field conditions it is probable that the chickens would catch and eat quite a few grasshoppers that had not been poisoned, while here, as nearly as was possible, every grasshopper fed the experimental chickens had been poisoned. Also, these grasshoppers had been caged where no other form of food was available except the poison bran. It seems probable that for this reason they may have contained more arsenic than those poisoned in the field where their natural food also was available.

Not only do these data show that the chickens are not killed in spite of the severity of the tests,but give very direct indications as to the reasons they are not killed.

The basic reason, entirely self-evident, is that they do not secure a sufficient amount of arsenic. The fact that the chickens lived is probably ample evidence for this statement, though the possibility exists that even though they secured a sufficient amount, it might have undergone such chemical changes in the alimentary canal of the grasshopper as to render it less toxic to the chickens. But if the method used in arriving at the amount of arsenic the grasshoppers consumed was accurate, these experiments show definitely that the chickens will not consume an amount of arsenic equal to a toxic or lethal dose, through feeding on grasshoppers that had been killed by feeding on poison bran. The following table serves to emphasize this point.

TABLE XXI

MAXIMUM PERCENTAGES OF A TOXIC DOSE OF ARSENIC CONSUMED BY CHICKENS

Chicken No.	Type of poison fed hoppers	Greatest % of toxic dose rec'd*	Remarks
29 & 30	As_2O_3	15.30	Fed poisoned hoppers and A. and M. growing ration for 66 days.
33 & 34	"	28.70	Fed poisoned hoppers and grain for 53 days.
37	"	53.14	Fed poisoned hoppers and A. and M. growing ration for 37 days.
39	"	26.13	Fed poisoned hoppers and grain for 20 days.
41	"	46.20	Fed poisoned hoppers only for 10 days.
43	Sodium arsenite	17.90	Fed poisoned hoppers and A. and M. growing ration for 10 days.
44	"	17.88	Fed poisoned hoppers and A. and M. growing ration for 10 days.
47	As_2O_3	21.77	Fed poisoned hoppers only for 10 days.
48	Sodium arsenite	10.27	Fed poisoned hoppers only for 10 days.
51	"	37.58	Fed poisoned hoppers only for 10 days.
	Average % -	27.487	

It will be seen from this table that slightly over one-half of a toxic dose was the largest amount consumed in any one day. Furthermore, as previously pointed out, the

*Does not include birds feeding on injected grasshoppers.

nearest to a toxic dose was always obtained during the first few days of the experiment and the longer the experiment continued the smaller the percentage of a toxic dose the chickens ate.

Also, these experiments continued so much longer than under field conditions that if there were any possibility of the arsenic having a cumulative effect, it certainly would have shown up before the close of the experiment.

It is true according to indications that the toxic dose of sodium arsenite is smaller than was assumed, but since it had already been proven that the chickens would not consume a toxic amount, no attempt was made to determine the exact amount constituting a toxic dose.

The reason the chickens secure such a small percentage of a toxic dose is also brought out in these data. This reason is that they eat fewer grasshoppers when they are poisoned. Totaling the number of grasshoppers eaten by all the chickens feeding on poisoned grasshoppers, we find the number to be 3421, while the chickens eating unpoisoned grasshoppers ate 5688. Thus, it is seen that those feeding on poisoned grasshoppers ate only 60.14 per cent as many as eaten by those feeding on unpoisoned grasshoppers. This, however, does not tell the entire story, for in a number of these experiments the chickens eating unpoisoned grasshoppers

were fed only the approximate number that the others ate. Also, in one of the experiments there were three chickens feeding on poisoned grasshoppers and only one check chicken. In order to show the correct percentage, the number of chickens should be the same. So, for the purpose of arriving at a more nearly accurate percentage of the number of grasshoppers eaten by chickens feeding on poisoned grasshoppers, it will be assumed that had two other checks been used they would have eaten the same number of grasshoppers eaten by the one that was used. By working under this assumption and eliminating those experiments where the check chickens were not fed all they would eat, the totals are as follows: Chickens fed unpoisoned grasshoppers ate 3696; those fed poisoned grasshoppers ate 1359. In this case, the percentage drops to 36.77 per cent which, in the writer's opinion, is much nearer the actual percentage they eat.

The reason for this lower amount of arsenic and smaller percentage of grasshoppers consumed was also quite clearly indicated. No. 51, which has already been discussed, showed about as clearly as a chicken could that she recognized the fact that the poisoned grasshoppers were injurious to her and therefore refused to eat more than a few even though no other food was to be had. She still further showed the ability to recognize the difference between poisoned and

unpoisoned grasshoppers by increasing her consumption of grasshoppers 3 to 4 hundred per cent within one and one-half days after she started receiving unpoisoned grasshoppers. A number of the chickens indicated the same thing, though none showed it quite as plainly as No. 51.

The effect that the poisoned grasshoppers had on the chickens is more difficult to determine. If we total the amount of weight gained during these experiments by chickens eating poisoned grasshoppers and subtract from this the amount of weight lost by those that lost weight during the experiments, we find the total gain for the chickens eating poisoned grasshoppers to be 98.85 ounces, as compared to 115.5 ounces gained by those eating unpoisoned grasshoppers. But this method of figuring also fails to tell the whole story because of the fact that there were two more chickens receiving poisoned grasshoppers than there were receiving unpoisoned grasshoppers. Also, in those experiments in which only grasshoppers and water were fed, the chickens eating poisoned grasshoppers invariably lost weight. This condition was so unnatural that the figures give very little indication as to the effect the poisoned grasshoppers might have had under field conditions. Therefore, a more nearly fair gauge of what might occur under field conditions would be obtained if those experiments where grasshoppers alone were fed were not used in calculating the total amount of weight gained. The

elimination of these experiments also results in the same number of checks and experimental chickens. In this case, the total gain for chickens eating poisoned grasshoppers is 125.85 ounces and for the checks, 112.5 ounces.

The result of the experiment appears to indicate that the chickens eating poisoned grasshoppers will outgain the others in weight under field conditions. The writer, however, attributes this difference more to the immense appetite of No. 43 for the first 10 days after she was brought from the farm and placed in the cage than to any effect the arsenic may have had.

The autopsies of 14 chickens show that of this number, 5 of the experimental chickens had enteritis of the digestive tract, and only 3 check chickens; 2 experimental chickens had ulceration of the gizzard, and 1 check chicken; 3 experimental chickens had kidneys inflamed or tubules swollen, and 1 check bird; 1 experimental bird had translucent muscles while this condition did not occur in any of the check birds. This indicates that such troubles are more common in chickens eating poisoned grasshoppers. To the writer, however, these data appear insufficient to justify the drawing of any conclusions.

A further attempt to obtain information as to the

effect the arsenic may have had was made by preparing slides of the liver, kidneys, heart, intestines, gizzard, and flesh of a number of experimental and check chickens; but these slides failed to reveal any histological changes whatever between the two groups.

(2) Conclusions. These data, to the writer, appear to justify the following conclusions.

1. Chickens will not be killed through feeding upon poisoned grasshoppers.

2. The eating of poisoned grasshoppers does not materially affect the growth of chickens or their gain in weight.

3. Chickens do not obtain a sufficient amount of arsenic through eating poisoned grasshoppers to affect them because they recognize the fact that too many poisoned grasshoppers are injurious to them, and therefore reduce the numbers they eat.

4. Usually chickens will consume less than one-half of a toxic dose of arsenic in the grasshoppers they eat.

5. They consume the greatest amounts of arsenic within the first few days and thereafter consume decidedly smaller amounts.

6. The arsenic will not have a cumulative effect on them even though they feed on poisoned grasshoppers over extended periods of time.

b. Experiments in feeding poisoned grasshoppers to turkeys. At the close of the experiments with chickens, it was desired to learn if other domestic fowls would react in the same manner to feeding upon poisoned grasshoppers. Time did not permit as extensive experiments as were carried on with chickens, but it was felt that if other fowls reacted in a similar way to a few experiments that would be a fairly strong indication that they would react similarly in a larger number.

Four turkeys were used in the next experiment, and were fed as indicated in Table XXII. At the close of this experiment, the check turkey, No. 56, which had been accustomed to eating large numbers of unpoisoned grasshoppers was placed on a diet of poisoned grasshoppers for 6 days. Tables XXII and XXIII give the results of these tests.

TABLE XXII

DATA ON FEEDING GRASSHOPPERS AND GROWING RATION TO TURKEYS

	Bird No. 53 - fed hoppers poisoned with sodium arsenite and bran: Wt. 1 lb. 15.5 oz.			Bird No. 54 fed injected hoppers Wt. 12 oz.			Bird No. 55 - fed hoppers poisoned with white arsenic and bran: Wt. 1 lb. 13 oz.			Bird No. 56 - fed unpoisoned hoppers 1 lb. 12 oz.
Date	No. eaten	% Poisoned	Amount arsenic in mgs.	No. eaten	Amount arsenic in mgs.		No. eaten	% poisoned	Amount arsenic in mgs.	No. eaten
7:30										
8 AM:	53	94.4	18.8245	14	26.8408		11	88.9	7.3587	44
5 PM:	0			0			16	88.9	10.7035	38
7-31										
8 AM:	0			2	3.8344		7	88.9	4.6828	58
5 PM:	0			0			1	88.9	.6690	36
8-1										
8 AM:	1	72.9	0.2743	0			4	88.9	2.6759	41
5 PM:	0			0			2	88.9	1.3378	50
8-2										
8 AM:	6	85.4	1.9279	0			2	90.8	1.3865	35
5 PM:	0			0			1	90.8	0.6832	25
8-3										
8 AM:	0			0			1	85.6	0.6441	55
5 PM:	3	85.4	0.9639	1	1.9172		2	85.6	1.2880	50
8-4										
8 AM:	0			0			3	85.6	1.9324	50
5 PM:	1	85.4	0.3213	0			0			49
8-5										
8 AM:	0			0			0			58
5 PM:	5	85.4	1.6066	0			2	85.6	1.2880	46
8-6										
8 AM:	0	85.4		0			0			49
5 PM:	1	85.4	0.3213	0			2	90.4	1.3605	48
8-7										
8 AM:	2	85.4	0.6426	0			0			66
5 PM:	5	85.4	1.6066	0			0			41
8-8										
8 AM:	5	87.5	1.6461	0			0			28
5 PM:	0			2	3.8344		3	90.4	2.0408	41
	82		28.1351	29	36.4268		57		38.0312	915

Weights 8-8, No. 53 - 2 lb. 5 oz; No. 54 - 1 lb. 9 oz.;
No. 55 - 2 lb. 8 oz.; No. 56 - 2 lb. 12 oz.

TABLE XXIII

DATA ON FEEDING POISONED GRASSHOPPERS AND GROWING RATION TO A TURKEY ACCUSTOMED TO EATING LARGE NUMBERS OF UNPOISONED GRASSHOPPERS

Turkey No. 56 - Weight 2 lb.12 oz.

Date	Hour	Hoppers poisoned with sodium arsenite and bran. No. eaten	% Poisoned	Amount arsenic, in mgs.
8-28	8 AM	36	88.9	12.0415
	5 PM	1	88.9	0.3345
8-29	8 AM	0		
	5 PM	4	88.9	1.3379
8-30	8 AM	2	88.9	0.6688
	5 PM	8	94.5	2.8444
8-31	8 AM	0	94.5	
	5 PM	1	94.5	0.3556
9-1	8 AM	0		
	5 PM	0		
9-2	8 AM	0		
	5 PM	0		
Total		52		17.5828

Notes - No. 53 had a mild case of diarrhoea beginning July 31. This was the only visible indication of poisoning. By Aug. 2, this bird appeared normal in every respect again and remained normal throughout the remainder of the experiment.

Nos. 55 and 56 at no time during the experiment exhibited any abnormal symptoms.

No. 54 appeared to be very ill at 5 P. M., July 30.

Stood with head drooping low and eyes closed, diarrhoea pronounced, faeces very watery, blackish to greenish in color, eyes slightly inflamed.

July 31 - Very little, if any, change.

Aug. 1 - Apparently is feeling better but does not appear to be feeding. Keeps eyes open most of the time and walks about the cage.

Throughout the balance of the experiment there was little change apparent in No. 54. She ate lightly of the mash and on two occasions ate more grasshoppers; one, one time and two the next. After the close of the experiment Aug. 9, this bird was kept in the cage for observation and was found dead the morning of Aug. 11.

Notes of autopsy - General condition very poor, alimentary tract entirely empty, severe enteritis of entire digestive tract, kidneys congested, muscle tone of gizzard poor, mesentery congested, many symptoms of starvation.

(1) Discussion. On the whole, the turkeys in this experiment appeared to be affected by the arsenic very similarly to chickens. This is seen by the fact that No. 53, after receiving 36.619 per cent of a theoretical toxic dose of sodium arsenite, was severely poisoned and No. 55 after eating 18.52 per cent of a toxic dose, did not appear to be affected in the least thereby. This is very similar

to the effect on chickens fed similarly.

The reaction of the turkeys to these amounts of arsenic differed in that, although they were similarly affected, they reduced the number of grasshoppers they would eat thereafter decidedly more than the chickens did.

Throughout the 10 days of the experiment, No. 53 ate only 9.06 per cent the number of grasshoppers eaten by the check bird, No. 54 - 3.20 per cent, and No. 55 - 6.32 per cent. These are distinctly smaller percentages than in chickens.

The check turkey (No. 56) gained 16 ounces during the experiment, while the two feeding on grasshoppers that had eaten poison bran (Nos. 53 and 55) gained but 17 ounces. This might be interpreted as evidence that Nos. 53 and 55 were injured by the arsenic and thus gained less proportionate weight. Another interpretation might be that the check turkey gained more on account of the greater number of grasshoppers eaten.

Table XXII shows No. 56 to have eaten 823 more grasshoppers than No. 53, and 848 more than No. 55. To the writer it appears that this may have had considerable influence.

(2) Conclusions. These data, while small in amount, permit the drawing of the following conclusions:

1. Even though turkeys have access to all the grasshoppers, poisoned by eating poisoned bran, that they will eat, they will not be killed nor noticeably injured by eating them. This conclusion may be drawn even though No. 54 died, since the grasshoppers this turkey ate contained a great deal more arsenic than any contained that were killed by eating poison bran.

2. They eat fewer poisoned than unpoisoned grasshoppers, thus limiting the amount of arsenic they receive.

3. Turkeys, after consuming a small amount of arsenic in poisoned grasshoppers, reduce the number of grasshoppers eaten to a greater extent than do chickens. This may be taken to indicate that turkeys are more susceptible to arsenical poisoning or that they react more readily to the same stimuli. The fact that No. 54 withstood the effect of arsenic as well as the chickens fed similarly, lends weight to the second view.

4. On account of the above, there is less danger of turkeys being injured through continued feeding on poisoned grasshoppers than of chickens.

c. Experiments in feeding poisoned grasshoppers to ducks. Knowing the reputation ducks have for being such heavy eaters, it was desired to see what effect poisoned grasshoppers as a diet might have on them. No ducks were available at the college poultry plant so these ducks were secured from a farm near Stillwater. They were of the Muscovy variety and were approximately 4/5 grown.

These ducks were fed as indicated in Table XXIV.

TABLE XXIV

DATA ON FEEDING GRASSHOPPERS AND KAFIR CORN TO DUCKS

	Bird No. 57 - fed hoppers poisoned with white arsenic and bran Wt. 4 lb. 12 oz.			Bird No. 58 - fed hoppers poisoned with sodium arsenite and bran Wt. 4 lb. 10 oz.			Bird No. 59: fed hoppers: injected with sodium arsenite. Wt.: 4 lb. 10 oz;		Bird No. 60 - fed unpoisoned hoppers Wt. 4 lb. 9 oz.
Date	No. eaten	% Poison	Amount Arsenic present in mgs.	No. eaten	% Poison	Amount arsenic present in mgs.	No. eaten	Amount arsenic	No. eaten
8-26									
5 PM:	75	82.1	46.3351	75	88.9	25.0865	37	77.1820	75
8-27									
8 AM:	75	82.1	46.3351	73	88.9	24.4175	dead		75
5 PM:	90	82.1	55.6022	100	88.9	33.4486			100
8-28									
8 AM:	53	82.1	32.7435	76	88.9	25.4209			79
5 PM:	38	82.1	23.4479	48	88.9	16.0553			50
8-29									
8 AM:	45	82.1	27.8011	44	88.9	14.7129			50
5 PM:	50	76	28.5950	50	88.9	16.7243			125
8-30									
8 AM:	38	76	21.7332	50	88.9	16.7243			50
5 PM:	55	76	31.4545	121	94.5	43.0823			125
8-31									
8 AM:	41	76	23.4479	50	94.5	17.7778			50
5 PM:	48	79	28.5348						50
9-1				Ran out of					
8 AM:	50	79	29.7237	grasshoppers					50
5 PM:	45	79	26.7513	Wt. 4 lb. 11 oz.					50
9-2									
8 AM:	46	79	27.3458						75
5 PM:	58	92.5	40.3716						60
9-3									
8 AM:	45	92.5	31.3228						45
5 PM:	50	92.5	34.8031						59
9-4									
8 AM:	41	92.5	28.5385						50
5 PM:	17	76.4	09.7734						50
9-5									
8 AM:	45	76.4	25.8709						55
5 PM:	39	76.4	22.4215						121
9-6									
8 AM:	25	76.4	14.3727						78
Total:	1069		657.3256	687		233.3904	37	77.1820	1513

Weight, 9-6 - No. 57 - 5 lb. 4 oz; No. 60 - 5 lb. 4 oz.

Notes - This table shows that the ducks consumed 435 grasshoppers the first day. At this time the species of grasshoppers being fed (M. bivittatus) were becoming quite scarce and the collecting of sufficient grasshoppers daily required several hours of time and a great deal of driving with the hopper dozer, as several fields had to be collected from in order to get the required number. This experiment was planned to be run only 10 days, but in the rush of securing a sufficient number of poisoned grasshoppers, it was not noticed that the time had expired and as a result, it was continued for 11 days instead of 10. After Aug. 30, it was not possible to keep a sufficient supply of poisoned grasshoppers for all three remaining ducks, so only two were fed after this date.

No unusual symptoms of any kind were noticed in Birds Nos. 57, 58, and 60. Bird No. 59, however, appeared distinctly uncomfortable 20 minutes after feeding, 8:30 A. M. The cage was not visited again until 3:45 P. M., at which time this bird was found dead, and apparently it had been dead for some time for it was beginning to stiffen.

Notes of autopsy - General condition good, most of grasshoppers partially digested, but still in digestive tract. Severe enteritis of alimentary canal. Diagnosis - arsenical poisoning.

(1) Discussion. Bird No. 57 consumed the largest amount of arsenic for any one day the first full day the experiment was run. On this day, Aug. 27, she consumed 101.9373 mg. arsenic, which is 39.88 per cent of the theoretical toxic dose. In spite of this, however, the daily consumption remained high throughout the experiment. Thus, it is seen the response was more similar to that of chickens than to that of turkeys.

No. 58 differed more from chickens than any of the other ducks. On Aug. 8 she consumed 57.8661 mgs. of arsenic in its soluble form, sodium arsenite. This is 46.50 per cent of the theoretical toxic dose. In the cases where chickens ate this great a proportionate amount of sodium arsenite, they lost their appetite for grasshoppers at once. In the case of this bird, however, while the daily consumption decreased to some extent, it was by no means as great as in the case of chickens, and no symptoms of poisoning appeared.

No. 59, feeding upon injected hoppers, consumed at the first feeding 77.1820 mgs. arsenic as the liquid sodium arsenite, which is 62.03 per cent of the theoretical toxic dose. This constitutes the largest dose received by any of the domestic fowls and death followed more quickly than in any other case, so it seems that here again we find ducks reacting to such feeding in very much the same manner that

chickens do.

No. 60, which ate a total of 1513 grasshoppers in 11 days, indicates that ducks will eat more grasshoppers per pound of body weight than either chickens or turkeys.

Since the check duck (No. 60) gained 12 ounces and No. 57 only 8 ounces, there is a slight advantage in this case in favor of the duck feeding on unpoisoned grasshoppers.

(2) Conclusions. These data, while limited, permit the drawing of the following conclusions:

1. Ducks may consume exceedingly large numbers of grasshoppers poisoned by feeding on poison bran and not be killed or noticeably injured.

2. Even though the grasshoppers are poisoned, ducks continue to eat a greater number in proportion to their weight than chickens or turkeys.

3. Arsenic is no more injurious to ducks, and perhaps less, than it is to chickens.

4. There may be greater danger to ducks in feeding on poisoned grasshoppers over a long period of time than to chickens on account of the fact that ducks do not reduce the number eaten as decisively as do chickens or turkeys.

d. Experiments in feeding poisoned grasshoppers to quail, Colinus virginianus (Linn.) Since in many cases where grasshopper bait is used, it is scattered directly over the feeding grounds of quail, many persons have thought that it is likely to result in the death of quail. Quail feed exclusively upon the ground and feed upon both grain and insects. Since they feed upon grain, they probably feed upon bran also. Therefore, in feeding over areas where poison bran has been spread and grasshoppers killed, it seems reasonable that they would feed upon both the poison bran and poisoned grasshoppers. Either of these, or the combination of the two, it is easy to imagine might result in their death.

Pettit (43) and Shoesmith (49) each states that poison bran should not be scattered where partridge and quail are likely to feed. If we accept this view, it is the equivalent of saying that most communities should never use poison bran.

Therefore, the importance of this point is such that more definite information concerning it is needed.

The quail for this experiment were furnished by the State Game Warden of Oklahoma. Some of them were shipped to Stillwater from Laredo, Texas, having been secured across the border in Mexico, and others were secured from a game farm in Oklahoma.

As shown on page 58, quail after being starved for

24 hours and then having poison bran scattered at the rate of 100 pounds per acre among them, suffered no noticeable ill effects. From this it was concluded that quail were not endangered through the scattering of poison bran.

It was learned soon after the quail were caged that in these cages quail would not eat as large numbers of grasshoppers as has been reported in a few instances. This perhaps was due to the small size of the cages and the numerous disturbances to which they were subjected.

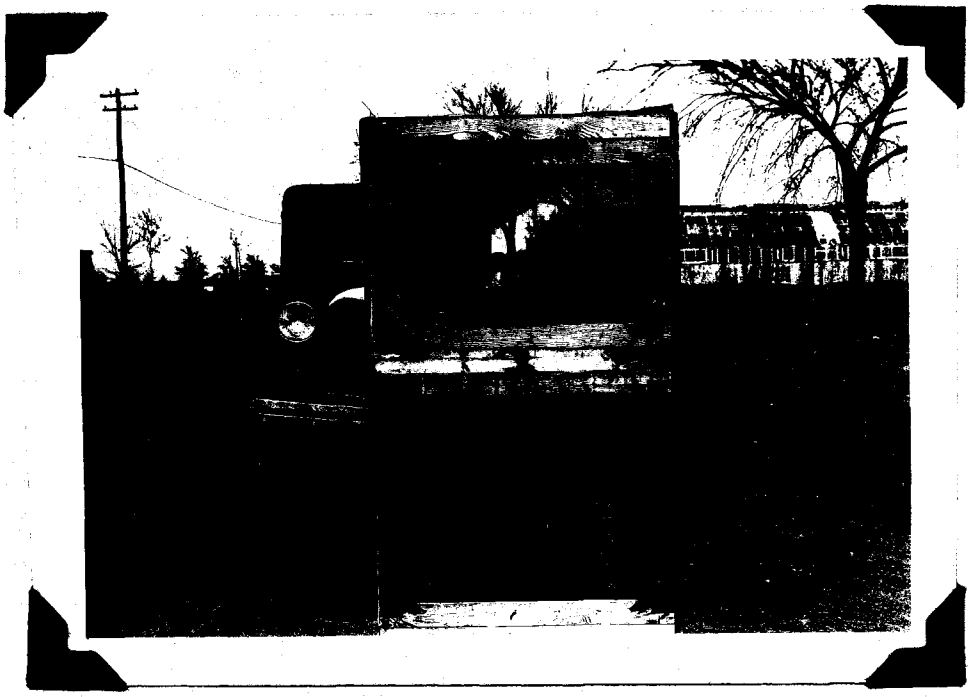

Fig. 19. Type of Cage in Which Quail Experiments were Conducted.

A great deal of data has been taken concerning the food habits of quail, but it has not been published in

such form as to give accurate information as to the maximum numbers of grasshoppers that quail may eat at any particular feeding. In most of the published articles along this line, lists of insects eaten by quail are given and the percentage of the total amount of food that these insects constitute is given, but the maximum numbers of grasshoppers eaten at any one time were found in only two publications. One of these was by Judd (31) in which he gives the data taken by Aughey in 1874-1875 in Nebraska during the outbreaks of the Rocky Mountain locusts (Melanoplus spretus, Uhler). "Stomach examinations of 21 quail showed 17 of the 21 birds had eaten grasshoppers, the average number being 25 and the greatest number 39." While it is not so stated, it is assumed that these were the Rocky Mountain locusts.

Nice (41), in feeding quail in pens, gives several records of much greater numbers of grasshoppers eaten than this. In one series of tests, one quail ate an average of 28 grasshoppers daily (size or species not stated). The one quail that had the greatest record of all is recorded as having eaten a total of 1532 insects in one day, 1000 of which were grasshoppers. These grasshoppers, however, must have been either first or second instar hoppers for the weight of the entire 1532 insects is given as 24.6 grams. Thus, if the entire 24.6 gms. had been made up of the 1,000

grasshoppers, the average weight per grasshopper would have been 0.0246 gms.

In the absence of more detailed published information, it was thought perhaps the Bureau of Biological Survey could furnish it. However, in reply to a letter of inquiry, Mr. Aughey's work as above referred to, was quoted and Mr. McAtee expressed his opinion that this was at least very near the maximum amount of grasshoppers quail would eat at any one feeding and a great deal more than normal.

It was therefore decided to conduct experiments under the assumption that 39 Rocky Mountain locusts was the maximum number of grasshoppers that quail would be likely to eat at any one feeding and 24.6 gms. of grasshoppers in any one day.

The Rocky Mountain locust, according to Comstock (6), is approximately the same size as M. femur rubrum. The species of grasshoppers used in this work, because it was most available at this time, was M. bispinosus. Since this species is slightly larger than M. spretus, it was assumed that M. bispinosus would consume at least as much poison as M. spretus. Since the earlier experiments reported in this paper gave the amount of arsenic consumed by M. bispinosus as .2991 mg., it appears that 39 times this amount, or 11.6644 mgs., would be the maximum amount of arsenic a quail could

obtain at any one feeding through eating grasshoppers.

The average weight of M. bispinosus was found to be .526 gms; therefore 24.6 gms. (the weight of all the insects eaten in a day, as recorded by Nice) ÷ .526 gms. or 46.77, equals the number of grasshoppers of this species that would weigh the maximum amount eaten by a quail in one day. Therefore, 46.77 x .2991 mgs. (amount arsenic consumed per grasshopper) or 13.9889 mgs. equals the maximum amount of arsenic a quail would obtain in any one day, even though he should eat the maximum amount of grasshoppers each of which was 100 per cent poisoned.

Therefore, it was felt that if the quail were fed 11.6649 mgs. arsenic in grasshoppers at one feeding and 13.9889 mgs mgs. in one day without injurious effects, this would constitute strong evidence that quail would not be endangered through having access to poisoned grasshoppers.

In the first experiment, 7 of the smaller grasshoppers per bird per day was the greatest number a quail would eat by merely throwing the grasshoppers before it. It was learned, however, that by catching the quail and placing a grasshopper well down in its throat it could be forced to eat at one feeding from 6 to 8 hoppers of the largest species used (M. bivittatus).

Under these circumstances the problem of feeding

the quail the desired amount of arsenic in the desired form, consisted of getting 6 to 8 grasshoppers to eat 11.6649 and 13.9889 mg. of arsenic respectively and force feed them to the quail. It was found that when the bran flakes contained a greater amount of arsenic than is contained in the standard mixture, many of the grasshoppers still ate almost as many flakes as when they contained only 4 per cent arsenic. Therefore, a batch of bran was mixed containing 12 per cent arsenic instead of 4 per cent. In mixing this, the arsenic was re-ground with a mortar and pestle and every precaution possible taken to see that it was thoroughly and evenly mixed.

Since this mash contained three times as much arsenic, each flake should contain three times as much arsenic as the 4 per cent arsenic mixture. As shown on page 69, the size of flake selected as a standard contained .09348 mg. of arsenic; therefore, in this mixture a flake of the same size would contain 3 x .09348 or .28044 mgs. of arsenic. 11.6649 ÷ .28044 = 41.59 and 13.9889 ÷ .28044 = 49.88 Therefore, if the number of grasshoppers that could be force fed to the quail at one time (6 to 8) could be induced to eat 41.59 and 49.88 flakes of this bran respectively, they would have consumed the desired amount for a maximum single feeding and maximum daily feeding.

(1) Methods. Grasshoppers (M. bivittatus) were placed in individual cages as before, with 15 carefully selected flakes of the standard size from the 12 per cent arsenic mixture. At death they were removed and the number of flakes they had eaten determined.

In feeding these larger grasshoppers to the quail, the legs and wings were clipped off close to the body and then force fed to the quail, as already described.

Table XXV gives the results of feeding tests when the grasshoppers were merely thrown before the quail on the floor of the cage. They were fed twice daily. The number of grasshoppers placed in the cage at each feeding was recorded. At the next feeding all uneaten grasshoppers were removed and fresh ones added. Thus a constant supply of fresh grasshoppers was before them at all times.

Quails Nos. 61 - 68 were used in an experiment to determine the possibility of quail being poisoned from eating scattered poisoned bran mash, as described on page 58 of this paper.

TABLE XXV.

DATA ON FEEDING GRASSHOPPERS AND GRAIN TO QUAIL.

Each cage contained 1 male and 1 female adult quail, weighing approximately 9 ounces.

Birds Nos. 69 and 70					Birds Nos. 71 and 72
Quail eating grasshoppers poisoned with white arsenic and bran					Quail fed unpoisoned grasshoppers
Date	Species hopper	No. eaten	% Poisoned	Amount arsenic, in mgs.	No. eaten
6-10	M. bis.	14	95	3.9780	18
6-11	" "	6	90	1.6151	2
6-12	" "	10	100	2.9910	10
6-13	M. fem.	10	100	2.8040	10
6-14	" "	10	90	2.5236	10
6-15	" "	10	95	2.6638	10
6-16	M. bis.	10	100	2.9910	10
6-17	" "	5	90	1.3459	3
6-18	M. fem.	6	84	1.4132	7
6-19	" "	10	88.8	2.4899	10
6-20	" "	8	94.7	2.1243	10
6-21	M. biv.	6	100	4.5150	4
6-22	" "	2	100	1.5050	5
6-23	" "	4	100	3.0100	2
6-24	" "	5	95	3.5743	4
6-25	" "	2	100	1.5050	3
6-26	" "	2	100	1.5050	1
6-27	M. fem.	5	86.6	1.2141	0
6-28	M. biv.	4	94.7	2.8504	1
6-29	" "	1	83.4	0.6276	4
6-30	" "	2	90	1.3545	1
7-1	M. bis.	4	88.8	1.0624	5
7-2	" "	5	90	1.3460	2
7-3	" "	5	90	1.3460	4
7-4	" "	6	90	1.6151	5
7-5	" "	4	100	1.1964	5
7-6	" "	6	94.7	1.6995	6
7-7	" "	6	82.3	1.4770	6
7-8	" "	6	100	1.7946	6
7-9	" "	6	82.3	1.4770	6

TABLE XXV.

DATA ON FEEDING GRASSHOPPERS AND GRAIN TO QUAIL (cont'd)

Birds Nos. 69 and 70					Birds Nos. 71 and 72
Quail eating grasshoppers poisoned with white arsenic and bran					Quail fed unpoisoned grasshoppers
Date	Species hopper	No. eaten	% Poisoned	Amount arsenic, in mgs.	No. eaten
7-10	M. bis.	6	100.3	1.4955	6
7-11	" "	5	100	1.4955	5
7-12	M. biv.	1	90	0.6773	0
7-13	M. bis.	5	100	1.4955	6
7-14	" "	5	100	1.4955	5
7-15	" "	7	100	2.0937	6
7-16	" "	6	100	1.7946	6
7-17	" "	6	100	1.7946	7
7-18	" "	6	90	1.6151	6
7-19	" "	6	80	1.4357	6
7-20	" "	5	88.2	1.3190	7
7-21	" "	5	100	1.4955	6
Total		242		79.8282	236

Notes - These birds remained very shy throughout the experiment, always hiding whenever anyone came near. As a result, very little was seen of them. However, at no time during the experiment could any symptoms of poisoning be detected.

Table XXVI gives the data on the tests, in which the quail were force fed the amount of arsenic they would obtain through eating 39 grasshoppers (M. bispinosus) 100 per cent poisoned, at a single feeding.

TABLE XXVI

DATA ON FORCE FEEDING GRASSHOPPERS TO QUAIL

Bird No. 73			Bird No. 74		Bird No. 75 (check)
Date	No. eaten	Amount arsenic* in mgs.	No. eaten	Amount arsenic, in mgs.	No. eaten
8-2	5	11.7784	5	12.0589	5
8-3	5	11.7784	6	12.6918	6
8-4	6	12.0589	5	11.7784	6
8-5	5	12.0589	6	12.9002	6
8-6	5	11.7784	5	11.7784	5
8-7			4	11.7784	4
8-8			5	11.7784	5
8-9			5	11.7784	5
8-10			5	11.7784	5
8-11			5	11.7784	5
Total:	26	54.4530	51	120.0997	52

Notes - No symptoms of poisoning were detected at any time throughout the experiment.

Table XXVII shows the data on the tests in which quail were force fed daily at least the amount of arsenic they would obtain through a maximum daily feeding on grasshoppers 100 per cent poisoned.

*At the first feeding of quail No. 73, one grasshopper had eaten 7 flakes of bran containing 12 per cent arsenic, two had eaten 9 flakes each, another 10 flakes, and another 6. Thus, a total of 42 flakes containing 11.7784 mg. of As_2O_3 had been eaten by the 5 hoppers fed. The amount of arsenic consumed at each feeding was figured by the same method, as was done in the following table.

TABLE XXVII

DATA ON FORCE FEEDING GRASSHOPPERS TO QUAIL

Bird No. 76			Bird No. 77			Bird No. 78 (check)
Date	No. eaten	Amount arsenic, in mgs.	No. eaten	Amount arsenic, in mgs.		No. eaten
8-12						
8:30 AM	3		3			3
4:30 PM	2	13.9887	2	14.3024		
8-13						
8:30 AM	3		3			2
4:30 PM	3	14.0220	3	14.3024		3
8-14						
8:30 AM	3		3			3
4:30 PM	3	14.0220	3	14.3024		3
8-15						
8:30 AM	3		3			3
4:30 PM	3	14.3024	3	14.3024		3
8-16						
8:30 AM	3		3			3
4:30 PM	2	14.3024	2	14.3024		2
8-17						
8:30 AM	3					3
4:30 PM	3	14.3024				3
8-18						
8:30 AM	4					4
4:30 PM	3	14.0220				3
8-19						
8:30 AM	3					3
4:30 PM	3	14.3024				3
8-20						
8:30 AM	3					3
4:30 PM	2	14.0220				2
8-21						
8:30 AM	3					3
4:30 PM	3	13.9887				3
Total	58	141.2750	28	71.5120		58

Notes - The birds remained normal throughout except that No. 78 (check) appeared sickly beginning Aug. 20 and died Aug. 23.

(2) Discussion. Here for the first time in any of the feeding experiments, the birds eating poisoned grasshoppers ate more than the check birds. This might be taken to mean that quail are not as quick to recognize the injurious nature of the arsenic they thus receive, and as a result, might be more nearly endangered through having access to the poisoned grasshoppers than chickens. Another explanation might be that in the number of grasshoppers consumed, there was not a sufficient amount of arsenic to be recognizable.

The writer is inclined to accept the second viewpoint, for the following reasons: (1) The greatest per cent of a toxic dose consumed was only 6.57 per cent, which is very small; (2) the check birds, No. 71 and 72, ate 18 grasshoppers the first day and then decreased the number eaten daily, even more than the experimental birds Nos. 69 and 70, which ate only 14 the first day.

Mr. McAtee, in the letter already referred to, states: "In the case of quail, it must be recognized that the bird is not a highly insectivorous species, only about a sixth of its animal food being insects. Of this amount, Orthoptera of all kinds constitute less than a fourth....." Therefore, it appears that the probable explanation of the fact that each pair consumed approximately the same number is that throughout the experiment they were eating as many grasshoppers as they

do normally over a period of several days. The experimental birds throughout the 42 days of the experiment ate an average of 5.79 grasshoppers daily.

During the summer of 1930 there was a severe outbreak of grasshoppers in the northwest corner of Oklahoma. One of the workers located there wrote that there were a large number of scaled quail (Callipepla squamata Vigors) feeding in this area. Therefore, a trip was made to this section to gather some information concerning the number of grasshoppers these birds would consume under such conditions. The species of grasshoppers found most abundant were Melanoplus differentialis(Thomas) and M. femur rubrum. Twelve quail were shot while feeding in fields abounding with grasshoppers and in the stomach contents of these 12 birds only one grasshopper was found.

This indicates that scaled quail are in less danger of being poisoned from eating poisoned grasshoppers than the Bob White. According to the figures on page 154, 11.6649 mg. is the maximum amount of arsenic a quail would obtain even though eating the maximum number of grasshoppers. This, however, constitutes only 38.54 per cent of the theoretical toxic dose. Table XXVI shows that two quail Nos. 73 and 74 each received a greater amount at a single feeding each day; No. 73 for 5 days and No. 74 for 10 days, and no injury resulted.

The maximum amount of arsenic a quail would obtain in one day figured 13.9889 mg. or 46.22 per cent of a toxic dose. Table XXVII shows that Quail No. 76 ate more than this amount daily for 10 days and No. 77 for 5 days and again no injury occurred.

(3) Conclusions.

1. Even though quail eat the maximum number of grasshoppers they have ever been recorded as having eaten, they will not be noticeably injured though each of the grasshoppers was killed by feeding on standard formula grasshopper bait.

2. Quail eating the number of grasshoppers normally eaten probably receive from 1 to 7 per cent of a toxic dose.

e. Experiments in feeding poisoned grasshoppers to song birds. In attempting to determine the effect arsenic may have upon birds of various species that may be present in the vicinity where grasshoppers are being poisoned, a number of difficulties arise. In the first place, the birds are not available except by trapping; also if trapped and caged, wild birds do not behave normally, do not feed normally and are difficult to keep alive. So many factors are involved in attempting to trap and feed them that it is extremely difficult to determine whether death is due to arsenic or to some

other factor; therefore, it was felt that better data would be obtained by some other method.

Another method of experimenting is that of taking the young birds before leaving the nests and rearing them by hand for feeding tests. At this time a nest of blue jays was found in which the young were ready to leave the nest. They all flew away as the nest was approached, but were captured and taken to the insectary and placed in a cage. Contrary to expectations, these young birds refused to open their mouths for food, and each time they were fed, their mouths were forced open and food placed well down in the throat. They were placed on a diet of grasshoppers, bread, and earth worms. In the succeeding one and one-half days, they were fed approximately 25 grasshoppers each. At the end of 24 hours, they appeared droopy and all died during the following day.

Fig. 20. Young Blue Jays Which Were Unable to Withstand Force Feeding of Grasshoppers.

A similar attempt was made with young robins but again all died within three days, making it impossible to draw any conclusions.

Knowing that crows are frequently raised by hand, a special attempt was made to obtain young crows. At least a dozen trips were made to various likely places looking for them. Quite a few of the nests that were discovered were in inaccessible places in the trees, and others when investigated, proved to be empty. The writer, in company with two boys, made several trips to a place where crows were known to nest 25 miles distant from Stillwater, and on one of these trips found a nest with young birds in it, but the birds were obviously too young to be taken from the nest at that time. A return trip revealed that some boys had evidently found the nest in the meantime, for it was found on the ground and the crows were gone. Later another nest was found on this place with young birds in it, and although it appeared that the birds were again too young to be taken from the nest, it seemed best to attempt to raise them rather than risk losing them as had happened before. These crows were accordingly brought in and placed in a cage. One of them died the second day, before poisoned grasshoppers were ready for feeding. Another was fed poisoned grasshoppers for two days and then was found dead the evening of the second

Fig. 21. Feeding a Young Crow.

day, and the following night rats killed the third one. Further search for young crows proved fruitless.

In summing up the results of these attempts to use hand raised nestling birds for determining the effect of poisoned grasshoppers, the most outstanding point seems to be the need of either better technique or another plan. In this case, another plan was adopted since it seemed to offer better promise, or at least quicker results.

Since the feeding of birds entirely by hand was unsuccessful, it was decided to supplement the feeding of nestling birds by their parents.

(1) Methods. In carrying out this plan, bird nests were found, and when the young birds were from 2 to 5 days old, regular trips were made to the nest and

grasshoppers fed to the young until they became old enough to leave the nest. Each bird was weighed the day the feeding was started. It was planned to weigh each bird at the close of the experiment also, but this soon proved to be impractical because of the fact that so many of the birds left the nest unexpectedly. Daily weighings were not considered practical on account of the fact that the birds were necessarily handled more than they should be during the process of feeding.

It was first thought that in order to feed the birds, all that would be necessary would be to drop the grasshoppers into the open mouths of the young birds; however, it was soon discovered that in a large per cent of the cases it was necessary to feed the young birds by force. The procedure in feeding was usually as follows: The bird was removed from the nest and held in the left hand. With the index finger of the right hand, its mouth was pried open and held in this position by means of the thumb and index finger of the left hand. The right hand was then free to insert a grasshopper well down into the throat of the bird. If the grasshopper was swallowed immediately, another was at once inserted. If the bird did not swallow, it was set down while the other birds were fed and the process was then repeated if it had swallowed in the meantime. This was repeated as often as it

was possible to get the birds to swallow.

During rains the birds were not fed in order to permit the parent birds to protect them from the rain.

Marking various parts of the body with paint or India ink was first tried as a means of identification, but this did not prove satisfactory so the method finally used was tying different colored strings around their legs. The constant handling of the birds that marking and feeding necessitated no doubt was detrimental to them and in all probability was a contributing factor to the death of many of those that died.

The birds were fed from two to five times daily. It is fully realized that the parent birds feed a great many more times than this, but the preliminary work indicated that when the birds were disturbed and handled more often the fatality rate ran so high among checks, as well as experimental birds, that most of the data was useless. Also, after feeding as heavily as possible at these intervals, it required a longer period before the birds would again feed. As a result, they could be fed nearly as many grasshoppers by feeding only three times as by feeding them five times a day.

A difficulty encountered was the disappearance of the birds from the nest in numerous instances. Sometimes this was undoubtedly due to predacious animals, as shown by blood,

portions of birds left, and torn nests. At other times, whole nests of birds would disappear, leaving no clue as to the cause. These cases also may have been due to some predator that worked in a different manner. In other cases, only one or two birds would disappear and these were more difficult to explain. It was thought that perhaps they died in the nest and were carried away some distance by the old birds and dropped. This theory was tested by placing dead young sparrows in a mocking bird's nest, containing living young, and watching the nest. A sparrow was placed in the nest at 5 P. M. while the young were being fed. The nest was observed for one hour and at the end of that time the sparrow was still in the nest. The next morning it was found on the ground approximately 10 feet from the nest. The following day another dead young sparrow was placed in the nest at 12:30 P. M. and observed until 7 P. M. at which time it was still in the nest. Again the following morning it was found about the same distance away. This experiment, of course, was entirely inadequate for the basing of opinions but did indicate that in case the birds died in the nest and were removed by the old birds, they could be found in the vicinity. Therefore, it was thought that those birds that completely disappeared should not be recorded as having died in the nest. Another fact that made this seem probable was that in many instances birds were found dead in

the nest, which apparently had been dead as long or longer than the time elapsing between visits to the nest from which birds had disappeared. Therefore, the data collected on birds that disappeared leaving no clue as to the cause of their disappearance, were not considered useful in arriving at conclusions.

Unless otherwise noted, all the grasshoppers fed in the following experiments were Melanoplus bispinosus and had been poisoned by means of white arsenic and bran. Before feeding, the hind legs were removed in order to prevent injury to the birds from the spurs of the tibia.

In the great majority of cases, the birds when nearly mature would leave the nest when it was approached, that otherwise would have remained in the nest a day or two longer. This, of course, was not a normal leaving of the nest, but appeared to be normal insofar as any effect their food might have on this action was concerned. Therefore, when the birds were approximately ready to leave the nest, their leaving was noted as normal even though they left slightly early due to disturbance.

It became apparent early in the feeding of nestling birds that the assumption we had been working under concerning the amount of arsenic constituting a lethal or toxic dose for domestic fowls and quail, would not stand the test of experiment

with nestling birds. From the data available, it was figured that 4.783 mgs. of As_2O_3 in the form of white arsenic, per ounce of bird weight, would constitute a lethal dose. Since there are 28.35 gms. per ounce, 4.783 ÷ 28.35 or .1687 mg. per gm. of bird weight should constitute a lethal dose. This being the case, 1.687 mgs. would constitute a lethal dose for a 10 gm. bird. It can be seen, however, by Table XXVIII that each bird receiving poisoned grasshoppers consumed more than this proportionate amount of arsenic each day throughout the experiment. No. 79 on June 16, weighing 17 gms., consumed 3.3738 mgs. or 117.64 per cent of a lethal dose, as calculated in feeding 1½ pound chickens. Therefore no reference is made to the percentage of a toxic or lethal dose in the following tables or discussion.

Tables XXVIII to XXXIII , inclusive, give the results of these feeding tests to five nests of mocking birds (Mimus polyglottos leucopterus, Vigors)

TABLE XXVIII

DATA ON FEEDING GRASSHOPPERS TO NESTLING MOCKING BIRDS

Date	% Poisoned	Poisoned grasshoppers: No. 79, Wt. 17 gms. — No. eaten	Amount arsenic, in mgs.	Poisoned grasshoppers: No. 80, Wt. 19 gms. — No. eaten	Amount arsenic, in mgs.	Unpoisoned grasshoppers: No. 81, Wt. 19 gms. — No. eaten
6-16						
9 AM:	94	4	1.1246	3	0.8435	2
12 AM:	94	2	0.5623	2	0.5623	2
1 PM:	94	2	0.5623	2	0.5623	2
6 PM:	94	4	1.1246	4	1.1246	4
6-17						
8 AM:	94	4	1.1246	4	1.1246	4
1 PM:	94	6	1.6869	4	1.1246	5
4 PM:	94	8	2.2492	8	2.2492	8
7 PM:	94	3	0.8435	3	0.8435	3
6-18						
12 AM:	94	4	1.1246	4	1.1246	4
5 PM:	94	8	2.2492	6	1.6869	6
6-19						
8 AM:	97	6	1.7408	8	2.3210	7
10 AM:	97	8	2.3210	8	2.3210	8
12 AM:	97	5	1.4506	6	1.7408	5
1 PM	97	5	1.4506	3	0.8704	5
6 PM	97	7	2.0309	7	2.0309	8
6-20						
8 AM:	97	8	2.3210	7	2.0309	8
12 AM:	97	5	1.4506	5	1.4506	5
5 PM:	97	6	1.7408	6	1.7408	6
Total:		95	27.1581	90	25.7525	92

Notes - These birds all left the nest normally and at no time was any evidence of poisoning detected.

The indications here are that nestling mocking birds may feed upon quite large numbers of poisoned grasshoppers without lethal or noticeable toxic effect, and develop as rapidly as those feeding upon unpoisoned grasshoppers.

TABLE XXIX

DATA ON FEEDING GRASSHOPPERS TO NESTLING MOCKING BIRDS

Date	% Poisoned	Poisoned grasshoppers: No. 82 Wt. 9 gms. No. eaten	Poisoned grasshoppers: No. 82 Wt. 9 gms. Amount arsenic, in mgs.	Poisoned grasshoppers: No. 83 Wt. 11 gms. No. eaten	Poisoned grasshoppers: No. 83 Wt. 11 gms. Amount arsenic, in mgs.	Unpoisoned grasshoppers: No. 84 Wt. 14.5 gm. No. eaten	Unpoisoned grasshoppers: No. 85 Wt. 12.5 gm. No. eaten
6-23							
9 AM	95	3	0.8524	3	0.8524	3	3
12 AM	95	2	0.5683	2	0.5683	2	2
5 PM	95	3	0.8524	3	0.8524	3	3
6-24							
9 AM	95	2	0.5683	2	0.5683	2	2
11 AM	95	2	0.5683	2	0.5683	2	2
		Dead		Dead		12	
						No.	Amt. Ars.	
6-25							
10 AM	100					2	0.5982	2
1:30	100					2	0.5982	2
3 PM	100					7	2.0937	6
6-26							
9 AM	100					2	.5982	2
1 PM	100					3	.8973	3
6-27							
8 AM	100					5	1.4955	5
10 AM	100					6	1.7946	6
1 PM	100					6	1.7946	5
4 PM	100					0		3
6-28							
8 AM	100					6	1.7946	6
1 PM	100					7	2.0937	7
5 PM	100					5	1.4955	6
6-29							
8 AM	100					5	1.4955	5
1 PM	100					8	2.3928	7
5 PM	100					10	2.9910	10
6-30							
9 AM	100					5	1.4955	5
11 AM	100					5	1.4955	5
Total		12	3.4097	12	3.4097	84	25.1244	97

Notes - No. 82 and No. 83 were found dead at 5 P. M. June 24th. Beginning 10 A. M., June 25th, No. 84 was placed on a diet of poisoned grasshoppers and No. 85 only remained as the check bird for the remainder of the experiment. Nos. 84 and 85 left the nest normally.

Comments - This experiment in the first one and one-half days indicated that the eating of poisoned grasshoppers will kill nestling birds since those eating poisoned grasshoppers died and the others lived. However, one of the check birds, when placed on a diet of poisoned grasshoppers, consumed more than seven times the amount of arsenic consumed by either of those that died, without any noticeable injurious effect. This might be taken as an indication that if very small birds are fed grasshoppers, they will be killed, but that larger birds can eat them without injurious effects.

Fig. 22. Mocking Bird Nest.

TABLE XXX

DATA ON FEEDING GRASSHOPPERS TO NESTLING MOCKING BIRDS

		Poisoned grasshoppers						Unpoisoned grasshoppers		
		No. 86 Wt. 7.5 gms.			No. 87 Wt. 7 gms.			No. 88 Wt.6 gm	No. 89 Wt.4.5 gm.	
Date	% Poisoned	No. eaten	Amount arsenic in mgs.		No. eaten	Amount arsenic, in mgs.		No. eaten	No. eaten	
6-24										
9 AM:	95	1	0.2841		1	0.2841		1	1	
12 AM:	95	1	0.2841		1	0.2841		1	1	
4 PM:	95	1	0.2841		1	0.2841		1	1	
6-25										
8 AM:	95	2	0.5683		2.	0.5683		2	2	
11 AM:	95	2	0.5683		2	0.5683		2	2	
2 PM:	95	2	0.5683		2	0.5683		2	2	
5 PM:	95	2	0.5683		2	0.5683		2	2	
6-26										
8AM	95	3	0.8524		3	0.8524		3	3	
12 AM:	95	4	1.1366		4	1.1366		4	4	
5 PM:	95	3	0.8524		3	0.8524		3	3	
Total:		21	5.9669		21	5.9669		21	21	

Notes - These birds were all progressing normally but during the night of June 26th, the nest was badly torn and all birds had disappeared.

In this experiment the birds, when first fed poisoned grasshoppers, were smaller than those recorded in Table XXIX that appeared to have been killed in one and one-half days through feeding on poisoned grasshoppers. Yet they lived three days on a diet of poisoned grasshoppers without any noticeable injurious effects, while the larger birds, presumably killed by such a diet, lived only one and one-half

days after being placed on the diet.

This refutes the indications obtained in the previous experiment that larger birds can consume poisoned grasshoppers without injury, but smaller birds will be killed.

TABLE XXXI

DATA ON FEEDING GRASSHOPPERS TO NESTLING MOCKING BIRDS

		Poisoned grasshoppers				Unpoisoned grasshoppers	
		No. 90 Wt. 34 gms.		No. 91 Wt. 36.5 gms.		No. 92: Wt. 28.5 gms	No. 93 Wt. 33.5 gm.
Date	% Poisoned	No. eaten	Amount arsenic in mgs.	No. eaten	Amount arsenic in mgs.	No. eaten	No. eaten
7-6							
3 PM:	94	8	2.2492	8	2.2492	8	8
8 PM:	94	2	0.5623	2	0.5623	2	2
7-7							
8 AM:	94	5	1.4058	5	1.4058	5	5
1 PM:	94	8	2.2492	0		8	0
3 PM:	94	0		0		5	0
Total:		23	6.4665	15	4.2173	28	15

Notes - These birds were almost ready to leave the nest when the experiment was started, and left the nest normally during the second day.

Owing to the limited time the experiment continued, little information of value in arriving at conclusions can be drawn. However, it does show that nearly mature mocking birds can consume as much as 3.6550 mgs. of arsenic in one day without injury.

TABLE XXXII

DATA ON FEEDING GRASSHOPPERS TO NESTLING MOCKING BIRDS

		Poisoned grasshoppers				Unpoisoned grasshoppers	
		No. 94 Wt. 29.5 gms.		No. 95 Wt. 28 gms.		No. 96 Wt. 28 gms.	No. 97 Wt. 31 gms.
Date	% Poisoned	No. eaten	Amount arsenic in mgs.	No. eaten	Amount arsenic in mgs.	No. eaten	No. eaten
7-6							
3 PM	94	5	1.4058	5	1.4058	5	5
8 PM	94	4	1.1246	4	1.1246	4	4
7-7							
8 AM	94	6	1.6869	6	1.6869	6	6
1 PM	94	5	1.4058	5	1.4058	5	5
5 PM	94	5	1.4058	5	1.4058	5	5
Total		25	7.0289	25	7.0289	25	25

Notes - A heavy, chilling rain began falling the night of July 7 and continued until nearly noon July 8th. The nest was visited shortly before noon and all four birds were found dead. It seemed probable that the combination of the disturbance and rain caused the parent birds to desert the nest, and the young died from exposure.

TABLE XXXIII

DATA ON FEEDING GRASSHOPPERS TO NESTLING MOCKING BIRDS

Date	% Poisoned	Poisoned grasshoppers: No. 98 Wt. 15 gms. No. eaten	Amount arsenic in mgs.	Poisoned grasshoppers: No. 99 Wt. 16 gms. No. eaten	Amount arsenic in mgs.	Unpoisoned grasshoppers: No. 100 Wt. 20 gms. No. eaten	Unpoisoned grasshoppers: No. 101 Wt. 10 gms. No. eaten
7-17							
8 AM:	94.6	1	0.2829	1	0.2829	1	1
11 AM:	94.6	2	0.5659	2	0.5659	2	2
5 PM:	94.6	2	0.5659	2	0.5659	2	2
7-18							
8 AM:	94.6	3	0.8488	3	0.8488	3	3
2 PM:	94.6	2	0.5659	2	0.5659	2	2
6:30	94.6	2	0.5659	2	0.5659	2	2
7-19							
8 AM:	94.6	3	0.8488	3	0.8488	3	3
7-20							
8 AM:	94.6	5	1.4147	Bird dis-		5	5
11:30:	94.6	2	0.5659	appeared		2	2
7-21							
8 AM:	94.6	2	0.5659			2	2
1 PM:	80	2	*1.2040			2	2
5 PM:	80	2	1.2040			2	2
7-22							
8 AM:	80	4	2.4080			4	4
1 PM:	80	4	2.4080			3	3
4 PM:	80	4	2.4080			4	4
7-23							
8 AM:	80	3	1.8060			2	3
1 PM:	80	2	1.2040			3	3
5 PM:	80	1	0.6020			2	2
Total:		46	20.0346	15	4.2441	46	47

Notes - The birds were fed only once July 19 on account of the rain. The morning of July 20, No. 99 had disappeared, leaving no clue at all as to the cause.

*M. bivittatus fed for the balance of the experiment.

Ran out of M. bispinosus July 21, 1 P. M., and fed M. bivittatus for the remainder of the experiment.

July 22, in the afternoon No. 98 and No. 101 each look sickly. July 23, their condition was worse - mouths yellowish, very droopy.

No. 100 left the nest normally at 8 A. M., July 24. Nos. 98 and 101 were both dead in nest at that time. The death of these two birds, together with the disappearance of No. 99, leaves insufficient data to be of much assistance.

The evidence brought out in these experiments is so conflicting that no conclusions should be drawn as to the injury of poisoned grasshoppers to nestling mocking birds without further information.

Table XXXIV gives the data on the feeding of grasshoppers to a nest of robins (Planesticus migratorius, Linn.)

Fig. 23. Feeding Robins.

TABLE XXXIV

DATA ON FEEDING GRASSHOPPERS TO ROBIN NESTLINGS

Date	% Poisoned	Poisoned grasshoppers No. 102 Wt. 4.3 gms. No. eaten	Amount arsenic, in mgs.	Poisoned grasshoppers No. 103 Wt. 4 gms. No. eaten	Amount arsenic in mgs.	Unpoisoned grasshoppers No. 104 Wt. 4.6 gms. No. eaten	Unpoisoned grasshoppers No. 105 Wt. 3.8 gms. No. eaten
6-9							
5 PM:	100	4	1.1964	2	0.5982	2	4
6-10							
7 AM:	100	3	0.8973	3	0.8973	4	4
10 AM:	100	4	1.1964	3	0.8973	3	4
1 PM:	100	9	2.6919	6	1.7946	6	9
5 PM:	100	8	2.3928	4	1.1964	4	8
6-11							
8 AM:	97.6	4	1.1676	4	1.1676	4	4
11 AM:	97.6	9	2.6273	5	1.4596	6	9
6-12							
3 PM:	100	8	2.3928	12	3.5892	6	5
6-13							
8 AM:	100	6	1.7946	10	2.9910	10	10
12 M:	100	4	1.1964	5	1.4955	5	6
5 PM:	100	10	2.9910	10	2.9910	10	10
6:14							
10 AM:	100	6	1.7946	6	1.7946	6	6
3 PM:	100	5	1.4955	5	1.4955	5	5
5:30	100	8	2.3928	8	2.3928	8	8
6-14							
7 AM:	100	15	4.4865	8	2.3928	8	15
11 AM:	100	10	2.9910	10	2.9910	10	
2 PM:	100	6	1.7946	11	3.2901	10	
5PM	100	15	4.4865	15	4.4865	15	
Total:		134	39.9860	127	37.9210	122	107

Notes - No. 105 fell out of the tree June 15 and struck the ground with such force that death resulted. All others left the nest normally.

Comments - Unfortunately no other nests of robins were fed. Robin's nests around the campus were very scarce at this time.

From this particular experiment, however, we may conclude that it is possible for a nestling robin to consume as many as 134 poisoned grasshoppers and mature normally.

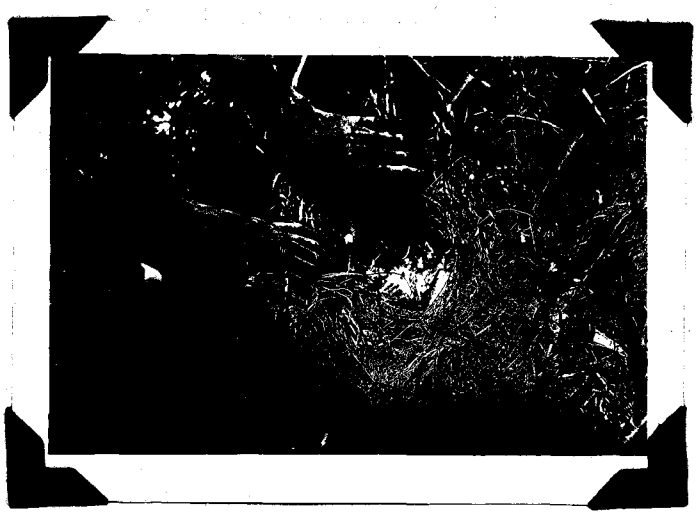

Fig. 24. Young Meadow Larks.

Tables XXXV to XXXVII give the data on the feeding of grasshoppers to nestling meadow larks (Sturnella magna, Linn.).

TABLE XXXV

DATA ON FEEDING GRASSHOPPERS TO NESTLING MEADOW LARKS

		Poisoned grasshoppers					Unpoisoned grasshoppers
		No. 106 Wt. 33.5 gms.		No. 107 Wt. 23 gms.			No. 108 Wt. 29.5 gms.
Date	% Poisoned	No. eaten	Amount arsenic, in mgs.	No. eaten	Amount arsenic in mgs.		No. eaten
7-8 4 PM:	92	5	1.3759	4	1.1007		4
7-9 8 AM:	92	6	1.6510	3	0.8255		6
11 AM:	92	4	1.1007	4	1.1007		4
5 PM:	94	5	1.4058	3	0.8435		4
7-10 9 AM:	94	5	1.4058	0			5
1 PM:	94	8	2.2492	0			8
5 PM:	94	7	1.9681	0			7
7-11 8 AM:	94	10	2.8115	0			10
11 AM:	94	2	0.5503	0			7
5 PM:	98	5	1.4656	0			7
Total:		57	15.9839	14	3.8704		62

Notes - These birds were heavily infested with mites. No. 107 was found dead in nest July 10 at 9 A. M., and No. 106 July 12 at 8 A. M. No. 108 appeared to be in good condition when the experiment was closed.

The indications here were that Nos. 106 and 107 were killed through feeding on poisoned grasshoppers.

TABLE XXXVI

DATA ON FEEDING GRASSHOPPERS TO NESTLING MEADOW LARKS

		Poisoned grasshoppers				Unpoisoned grasshoppers	
		No. 109 Wt. 28 gms.		No. 110 Wt. 23 gms.		No. 111 Wt. 13 gms.	No. 112 Wt. 24 gms.
Date	% Poisoned	No. eaten	Amount arsenic in mgs.	No. eaten	Amount arsenic in mgs.	No. eaten	No. eaten
6-17							
9 AM:	94	2	0.5623	2	0.5623	2	2
11 AM:	94	7	1.0681	5	1.4058	3	5
3 PM:	94	2	0.5623	3	0.8435	2	5
8 PM:	94	2	0.5623	2	0.5623	2	2
6-18							
9 AM:	94	2	0.5623	6	1.6869	3	4
1 PM:	94	5	1.4058	2	0.5623	2	4
5 PM:	94	3	0.8435	4	1.1246	4	4
6-19							
8 AM:	97	3	0.8703	1	0.2901	5	3
11 AM:	97	8	2.3210	2	0.5802	3	2
1 PM:	97	3	0.8703	3	0.8703	4	2
5 PM:	97	2	0.5802	2	0.5802	4	3
6-20							
8 AM:	97			4	1.1605	5	6
11 AM:	97			1	0.2901	1	1
3 PM:	97			3	0.8703	3	3
6-21							
9 AM:	97			2	0.5802	6	4
2 PM:	97			4	1.1605	4	5
7 PM:	97			2	0.5802	2	2
6-22							
9 AM:	97			12	3.4812	4	6
Total:		39	11.1084	60	17.1918	59	63

Notes - No. 109 was found dead in nest June 20 at 8 A. M. No. 110 left the nest normally June 23rd at 8 A. M. and experiment was discontinued.

Comments - This experiment indicates that No. 109

was killed by feeding on poisoned grasshoppers. On the other hand, No. 110, a smaller bird, consumed more grasshoppers and arsenic and matured normally.

TABLE XXXVII

DATA ON FEEDING GRASSHOPPERS TO NESTLING MEADOW LARKS

	Poisoned grasshoppers			Unpoisoned grasshoppers
	No. 113			No. 114
	Weight - 39 gms.			Weight - 43 gms.
Date	% Poisoned	No. eaten	Amount arsenic, in mgm	No. eaten
6-17				
4 PM	97	8	2.3210	3
8 PM	97	10	2.9012	3
6-18				
9 AM	97	7	1.9759	3
1 PM	97	2	0.5802	2
5 PM	97	4	1.1605	3
6-19				
8 AM	97	7	1.9759	0
Total		38	10.9147	14

Notes - It was desired to extend the feeding period beyond the time the birds normally leave the nest. It is known that the parent birds continue feeding the young after they leave the nest; therefore it was thought that if the young could be forced to remain in the vicinity of the nest the old birds would continue feeding and the supplementary feeding could also be continued over a longer period.

When this nest was found, the birds were nearly

ready to leave the nest. In order to try out the plan, a twine string was tied around the leg of each of the birds and tied to large nails driven in the ground.

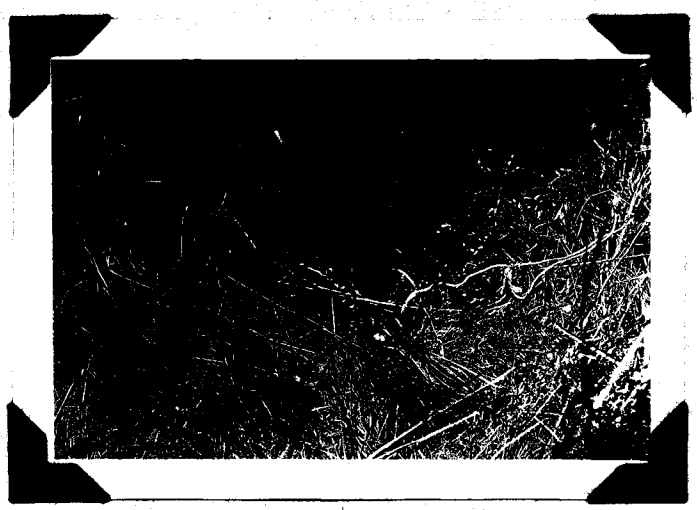

Fig. 25. Meadow Lark No. 113.

In order to shorten the time necessary to remain in the vicinity, only two birds were fed, No. 113 and No. 114; the other four, Nos. 115 - 118 were tied down but were fed no grasshoppers.

The parent birds were observed to feed them but the young did not live long. No. 115 and No. 117 died June 18 and Nos. 114 and 118 were found dead June 19 at 8 A. M. Only two birds were left and one of these, No. 116, was beginning to appear sickly, and therefore the experiment was discontinued. In this case, the bird receiving poisoned grasshoppers was in better condition than any of the other five.

Comments - Here again conflicting evidence does not permit the drawing of conclusions concerning the injury by poisoned grasshoppers to meadow lark nestlings.

Tables XXXVIII to XL give the data on the feeding of grasshoppers to the nestlings of red winged blackbirds (Agelaius phoeniceus, Linn.).

TABLE XXXVIII

DATA ON FEEDING GRASSHOPPERS TO NESTLING RED WINGED BLACKBIRDS

		Poisoned grasshoppers					Unpoisoned grasshoppers	
		No. 119 Wt. 15 gms.		No. 120 Wt. 13.5 gms.			No. 121 Wt. 9 gms.	No. 122 Wt. 15 gms.
Date	% Poisoned	No. eaten	Amount arsenic, in mgs.	No. eaten	Amount arsenic, in mgs.		No. eaten	No. eaten
6-29								
10 AM	100	2	0.5982	2	0.5982		2	2
3 PM	100	3	0.8973	3	0.8973		3	3
6-30								
11 AM	100	4	1.1964	4	1.1964		4	4
5 PM	100	4	1.1964	4	1.1964		4	4
7-1								
9 AM	100	3	0.8973	3	0.8973		3	5
5 PM	100	3	0.8973	3	0.8973		5	5
7-2								
8 AM	100	3	0.8973	3	0.8973		3	3
5 PM	97	4	1.1605	4	1.1605		4	4
7-3								
9 AM	97	5	1.4506	5	1.4506		5	5
5 PM	97	4	1.1605	4	1.1605		4	4
7-4								
9 AM	97	3	0.8704	3	0.8704		3	3
Total		38	11.2222	38	11.2222		40	42

Notes - On July 4 there was a very high wind and heavy rain of short duration. These birds were nearly mature

and had disappeared when the nest was next visited after the rain. Since the nest was in a small willow that must have swayed violently during the wind, it seems probable that they were blown from the nest. They all appeared normal and were so nearly mature that, for our purposes, they can be classified as having matured normally. In that case, it can be said that the indications here are that nestling blackbirds can consume considerable numbers of poisoned grasshoppers without injury.

TABLE XXXIX

DATA ON FEEDING GRASSHOPPERS TO NESTLING RED WINGED BLACKBIRDS

	Poisoned grasshoppers						Unpoisoned grasshoppers
	No. 123 Wt. 21 gms.			No. 124 Wt. 23 gms.			No. 125 Wt. 22.5 gms.
Date	% Poisoned	No. eaten	Amount arsenic, in mgs.	No. eaten	Amount arsenic, in mgs.		No. eaten
6-29							
10 AM	100	6	1.7946	6	1.7946		6
5 PM	100	5	1.4955	5	1.4955		5
6-30							
9 AM	100	5	1.4955	5	1.4955		5
4 PM	100	4	1.1964	4	1.1964		4
7-1							
9 AM	97	5	1.4506	5	1.4506		0
5 PM	97	7	2.0309	7	2.0309		0
7-2							
8 AM	97	0		7	2.0309		
7-3							
8 AM	97	0		4	1.1605		
5 PM	97	0		4	1.1605		
Total		32	9.4635	47	13.8154		20

Notes - No. 125 fell from the nest and was fatally injured, on July 1.

July 2, 8 A. M. No. 123 was found dead in the nest.

July 4, No. 124 left the nest normally.

The indications here are that No. 123 was injured through feeding on poisoned grasshoppers, although No. 124 was not.

TABLE XL

DATA ON FEEDING GRASSHOPPERS TO NESTLING RED WINGED BLACKBIRDS

		Poisoned grasshoppers					Unpoisoned grasshoppers
		No. 126 Wt. 11 gms.		No. 127 Wt. 14 gms.			No. 128 Wt. 15.5 gms.
Date	% Poisoned	No. eaten	Amount arsenic in mgs.	No. eaten	Amount arsenic in mgs.		No. eaten
7-1							
9 AM	100	3	0.8973	3	0.8973		3
5 PM	100	2	0.5982	2	0.5982		2
7-2							
8 AM	100	2	0.5982	2	0.5982		2
5 PM	97	0		3	0.8704		3
7-3							
9 AM	97			4	1.1605		4
5 PM	97			4	1.1605		4
7-4							
9 AM	97			3	0.8704		0
Total		7	2.0937	21	6.1555		18

Notes - No. 126 was found dead in nest June 2, at 5 P. M. On July 4, at 9 A. M. No. 128 leaped from nest and was injured. The same day at 6:30 P. M., No. 127 had disappeared, because of wind and heavy rain that afternoon.

The results of this experiment were very similar to the preceding one.

The indications from the experiments with red winged blackbirds are that though the grasshoppers may kill some of the birds the greater percentage of them are unaffected.

Tables XLI to XLV, inclusive, give the data on the feeding of grasshoppers to the nestlings of brown thrashers (Toxostoma rufum, Linn.)

TABLE XLI

DATA ON FEEDING GRASSHOPPERS TO NESTLING BROWN THRASHERS

		Poisoned grasshoppers				Unpoisoned grasshoppers	
		No. 129 Wt. 9 gms.		No. 130 Wt. 12 gms.		No. 131 Wt. 8 gms.	No. 132 Wt. 14 gms.
Date	% Poisoned	No. eaten	Amount arsenic in mgs	No. eaten	Amount arsenic in mgs.	No. eaten	No. eaten
6-22							
8 AM	97	4	1.1605	4	1.1605	4	4
12 AM	97	5	1.4506	4	1.1605	4	5
4 PM	97	2	0.5803	2	0.5803	2	2
Total		11	3.1914	10	2.9013	10	11

Notes - On June 23, 8 A. M. the nest was found badly torn; apparently the nest had been robbed during the night.

TABLE XLII

DATA ON FEEDING GRASSHOPPERS TO NESTLING BROWN THRASHERS

		Poisoned grasshoppers				Unpoisoned grasshoppers
		No. 133 Wt. 31 gms.		No. 134 Wt. 27 gms.		No. 135 Wt. 29.5 gms.
Date	% Poisoned	No. eaten	Amount arsenic, in mgs.	No. eaten	Amount arsenic, in mgs.	No. eaten
6-25						
10 AM	95	10	2.8414	10	2.8414	10
2 PM	95	4	1.1366	0		4
5 PM	95	6	1.7048	2	0.5683	7
Total		20	5.6828	12	3.4097	21

Notes - These birds were heavily infested with mites and appeared to be in poor condition when found.

June 26 at 8:30 A. M. No. 134 was found dead on ground; Nos. 133 and 135 dead in the nest.

TABLE XLIII

DATA ON FEEDING GRASSHOPPERS TO NESTLING BROWN THRASHERS

		Poisoned grasshoppers				Unpoisoned grasshoppers
		No. 136 Wt. 7 gms.		No. 137 Wt. 8.5 gms.		No. 138 Wt. 9.5 gms.
Date	% Poisoned	No. eaten	Amount arsenic in mgs.	No. eaten	Amount arsenic in mgs.	No. eaten
6-27						
10:30	95	1	0.2841	1	0.2841	1
1 PM	95	1	0.2841	1	0.2841	1
4 PM	95	1	0.2841	1	0.2841	1
6-28						
8 AM	95	2	0.5682	1	0.2841	0
Total		5	1.4205	4	1.1364	3

Notes - These birds, although quite small, appeared to be in good condition when found. However, at 11 A. M. June 28, No. 136 and No. 138 were dead and No. 137 almost dead. No. 137 was found dead at 2 P. M.

TABLE XLIV

DATA ON FEEDING GRASSHOPPERS TO NESTLING BROWN THRASHERS

		Poisoned grasshoppers				Unpoisoned grasshoppers
		No. 139 Wt. 23 gms.		No. 140 Wt. 25 gms.		No. 141 Wt. 28.5 gms.
Date	% Poisoned	No. eaten	Amount arsenic in mgs.	No. eaten	Amount arsenic in mgs.	No. eaten
7-6						
8 AM	94	4	1.1246	4	1.1246	4
12 AM	94	5	1.4056	0		5
3 PM	94	6	1.6869	0		6
8 PM	94	0		0		9
7-7						
8 AM		0		0		4
Total		15	4.2171	4	1.1246	28

Notes - No. 140 was found on the ground at noon, July 6. No. 139 was sickly at 8 P. M. July 6, and on the ground dead the following morning.

No. 141 appeared to be in good condition when the experiment was discontinued.

TABLE XLV

DATA ON FEEDING GRASSHOPPERS TO NESTLING BROWN THRASHERS

	Poisoned grasshoppers			Unpoisoned grasshoppers
	No. 142 Wt. 36 gms.			No. 143 Wt. 37.5 gms.
Date	% Poisoned	No. eaten	Amount arsenic, in mgs.	No. eaten
7-15				
9 AM	94.5	5	1.4132	4
1 PM	94.5	4	1.1306	4
5 PM	0	0		4
7-16				
8 AM		0		5
1 PM		0		5
5 PM		0		7
7-17				
8 AM		0		6
11 AM		0		5
5 PM		0		7
7-18				
8 AM		0		8
2 PM		0		8
6 PM		0		7
7-19				
8 AM		0		8
7-20				
8 AM		0		4
11 AM		0		9
7-21				
8 AM		0		0
Total		9	2.5438	91

Notes - No. 142 had disappeared at 5 P. M. July 15 after eating poisoned grasshoppers. Only one bird was left in the nest but experiment was continued to see if it would live under such treatment. No. 143 left nest normally July 21, 11 A. M. when nest was approached.

Comments - In summing up the experiments with brown thrashers, it is seen that a total of 15 birds were fed. Of these 9 were fed poisoned grasshoppers and 6 unpoisoned grasshoppers. Of the 9 receiving poisoned hoppers, 1 disappeared, 3 were found dead on the ground and 3 dead in the nest and 2 were destroyed, probably by some predator. Of the 6 receiving unpoisoned grasshoppers, 2 were destroyed, probably by some predator, 2 died in the nest, 1 matured normally and the experiment was discontinued before the fate of the last one was determined.

The most outstanding indication here seems to be that brown thrasher nestlings will not survive the treatment necessary to carry on these experiments as conducted. It also appears that the poisoned grasshoppers were an additional contributing factor in the death of these birds since all receiving poisoned grasshoppers died, but two of those receiving unpoisoned grasshoppers did not die.

Fig. 26. Dickcissel Nest.

Tables XLVI and XLVII give the data on the feeding of grasshoppers to the nestlings of dickcissels (Spiza americana Gmel.)

TABLE XLVI

DATA ON FEEDING GRASSHOPPERS TO DICKCISSEL NESTLINGS

		Poisoned grasshoppers				Unpoisoned grasshoppers	
		No. 144 Wt. 15.5 gms.		No. 145 Wt. 9 gms.		No.146 Wt. 12.5 gm	No.147 Wt. 13 gms.
Date	% Poisoned	No. eaten	Amount arsenic in mgs.	No. eaten	Amount arsenic in mgs.	No. eaten	No. eaten
6-17							
10 AM	94	2	0.5623	2	0.5623	2	2
3 PM	94	3	0.8433	2	0.5623	3	3
				4	1.1246		
				Fed No. 146 poisoned hoppers			
5 PM	94	3	0.8433		0.8433	3	3
8 PM	94	2	0.5623		0.5623	2	2
6-18							
8 AM	94	2	0.5623		0.5623	2	2
8 AM	94	2	0.5623		0.8433	3	2
1 PM	94	2	0.5623		0.5623	2	3
5 PM	94	2	0.5623		0.8433	3	3
7 PM	97	2	0.5802		0.5802	2	2
6-19							
8 AM	97	3	0.9804		0.8704	3	2
1 PM	97	2	0.5802		0.8704	3	2
4 PM	97	6	1.7408		0.5802	2	4
6-20							
8 AM	97	4	1.1605		0.8704	3	3
Total		35	9.9925		7.9884	33	33

Notes - No. 145 fell from the nest and was fatally

injured at 3 P. M. July 17. Beginning with the next feeding, No. 146 was fed poisoned grasshoppers until the end of the experiment.

TABLE XLVII

DATA ON FEEDING GRASSHOPPERS TO DICKCISSEL NESTLINGS

		Poisoned grasshoppers				Unpoisoned grasshoppers	
		No. 148 Wt. 23 gms.		No. 149 Wt. 15 gms.		No. 150: Wt. 16 gms.	No. 151 Wt. 21 gms.
Date	% Poisoned	No. eaten	Amount arsenic in mgs.	No. eaten	Amount arsenic in mgs.	No. eaten	No. eaten
6-16							
8 AM	94	1	0.2811	2	0.5623	3	4
11 AM	94	4	1.1246	3	0.8435	2	3
2 PM	94	2	0.5623	2	0.5623	2	2
8 PM	94	2	0.5623	2	0.5623	2	2
6-17							
8 AM	94	4	1.1246	0		4	0
3 PM	94	4	1.1246	0		4	0
7 PM	94	4	1.1246	0		4	0
6-18							
8 AM	94	4	1.1246	0		4	0
11 AM	94	5	1.4058	0		3	0
Total		30	8.4345	9	2.5304	28	11

Notes - Birds Nos. 149 and 151 disappeared the night of June 16, leaving no clue as to the cause of their disappearance. Nos. 148 and 150 matured and left the nest normally.

Comments - In this, as well as previous experiment, the results were identical with the birds receiving poisoned and unpoisoned grasshoppers.

Table XLVIII gives the data on feeding grasshoppers to two nestling orchard orioles (Icterus spurius, Linn.)

TABLE XLVIII

DATA ON FEEDING GRASSHOPPERS TO NESTLING ORCHARD ORIOLES

		Poisoned grasshoppers		Unpoisoned grasshoppers
		No. 152		No. 153
		Wt. 16 gms.		Wt. 11 gms.
Date	% Poisoned	No. eaten	Amount arsenic, in mgs.	No. eaten
6-26				
5 PM	95	2	0.5683	2
6-27				
9 AM	95	4	1.1366	2
1 PM	95	3	0.8524	3
4 PM	95	2	0.5683	2
6-28				
9 AM	100	3	0.8973	3
1 PM	100	3	0.8973	3
5 PM	100	2	0.5982	2
6-29				
8 AM	100	3	0.8973	3
12 AM	100	3	0.8973	3
5 PM	100	3	0.8973	3
6-30				
9 AM	100	4	1.1964	5
12 AM	100	5	1.4955	5
Total		37	10.9022	36

Notes - No. 152 left the nest normally June 30 at 3 P. M. and the experiment was discontinued, leaving No. 153 in the nest.

The indications in this experiment are that poisoned grasshoppers have no effect on nestling orchard orioles.

Table XLIX gives the data on the feeding of grasshoppers to the nestlings of western lark sparrows (Chondestes grammacus strigatus Swains)

TABLE XLIX

DATA ON FEEDING GRASSHOPPERS TO NESTLING LARK SPARROWS

		Poisoned grasshoppers				Unpoisoned grasshoppers	
		No. 154 Wt. 13.5 gms.		No. 155 Wt. 16 gms.		No. 156; Wt. 15 gms.	No. 157 Wt. 13 gms.
Date	% Poisoned	No. eaten	Amount arsenic, in mgs.	No. eaten	Amount arsenic, in mgs.	No. eaten	No. eaten
7-14							
9 AM:	94.5	1	0.2826	1	0.2826	1	1
1 PM:	94.5	1	0.2826	1	0.2826	1	1
5 PM:	94.5	1	0.2826	1	0.2826	1	1
7-15							
8 AM:	94.5	2	0.5652	0		2	2
1 PM:	94.5	3	0.8413	0		0	3
5 PM:	94.5	3	0.8413	0		0	2
Total:		11	3.0956	3	.8478	5	10

Notes - When this experiment was started and the birds weighed, it was noticed that No. 155 was very lively, crawling about a great deal. It was expected that this bird would fall from the nest during handling. This occurred when it was replaced in the nest at 5 P. M. The following day at 1 P. M., No. 156 fell and was injured. The morning of July 16 all birds had disappeared, though too immature to leave the nest.

Table L gives the data on feeding grasshoppers to the nestlings of scissor-tailed flycatchers (Muscivora

forficata Gmel.)

TABLE L

DATA ON FEEDING GRASSHOPPERS TO SCISSOR-TAIL NESTLINGS

Date	% Poisoned	Poisoned grasshoppers No. 158 Wt. 17 gms. No. eaten	Amount arsenic in mgs.	Poisoned grasshoppers No. 159 Wt. 19 gms. No. eaten	Amount arsenic in mgs.	Unpoisoned grasshoppers No. 160 Wt. 20.5 gms. No. eaten	Unpoisoned grasshoppers No. 161 Wt. 19,5 gms. No. eaten	Unpoisoned grasshoppers No. 162 Wt. 12 gms. No. eaten
7-14 :								
9 AM:	94.6	0		1	0.2829	1	1	1
1 PM:	94.6	1	0.2829	1	0.2829	1	1	1
5 PM:	94.6	1	0.2829	1	0.2829	1	1	1
7-15 :								
8 AM:	94.6	1	0.2829	1	0.2829	1	1	1
2 PM:	94.6	1	0.2829	1	0.2829	1	1	1
5 PM:	94.6	1	0.2829	1	0.2829	1	1	1
7-17 :								
8 AM:	94.6	1	0.2829	1	0.2829	1	1	1
11 AM:	94.6	2	0.5659	2	0.5659	2	2	2
5 PM:	94.6	2	0.5659	2	0.5659	2	2	2
7-18 :								
8 AM:	94.6	2	0.5659	2	0.5659	2	2	2
2 PM:	94.6	2	0.5659	2	0.5659	2	2	2
6:30 :	94.6	2	0.5659	2	0.5659	2	2	2
7-19 :								
8 AM:	94.6	2	0.5659	2	0.5659	2	2	2
2 PM:	94.6	2	0.5659	2	0.5659	2	2	2
7-20 :								
8 AM:	94.6	2	0.5659	2	0.5659	2	2	2
11:30:	94.6	2	0.5659	2	0.5659	2	2	2
7-21*:								
1 PM:	80.0	2	1.2040	2	1.2040	2	2	2
5 PM:	80.0	2	1.2040	2	1.2040	0	2	2
7-22 :								
8 AM:	80.0	2	1.2040	2	1.2040	0	2	0
1 PM:	80.0	2	1.2040	2	1.2040	0	2	0
Total:		32	11.8894	32	12.1723	27	33	29

*M. bivittatus fed after this date.

Notes - Although these birds were quite large, as compared to some other species that were fed, it was extremely difficult to get them to swallow the grasshoppers and two was the greatest number that could be forced down them at any one feeding. It was expected that the majority or all would die because so much handling was necessary. However, all reached maturity and left the nest normally.

The indications here are that the poisoned grasshoppers had no effect.

Tables LI and LII give the data on the feeding of grasshoppers to nestlings of English sparrows (Passer domesticus Linn.)

TABLE LI

DATA ON FEEDING GRASSHOPPERS TO ENGLISH SPARROW NESTLINGS

Date	% Poisoned	Poisoned grasshoppers: No. 163 Wt. 16 gms. — No. eaten	Amount arsenic, in mgs.	Poisoned grasshoppers: No. 164 Wt. 16 gms. — No. eaten	Amount arsenic, in mgs.	Unpoisoned grasshoppers: No. 165 Wt. 24.5 gms. — No. eaten	Unpoisoned grasshoppers: No. 166 Wt. 22 gms. — No. eaten	Unpoisoned grasshoppers: No. 167 Wt. 11.5 gms. — No. eaten
7-7								
1 PM:	92	3	0.8255	3	0.8255	3	3	3
5 PM:	92	2	0.5503	2	0.5503	2	2	2
7-8								
1 PM:	92	3	0.8255	3	0.8255	3	3	3
5 PM:	92	2	0.5503	2	0.5503	2	2	2
7-9								
8 AM:	92	3	0.3255	3	0.8255	3	3	3
1 PM:	94	2	0.5623	2	0.5623	2	2	2
5 PM:	94	2	0.5623	2	0.5623	2	2	2
7-10:								
8 AM:	94	2	0.5623	2	0.5623	2	2	2
1 PM:	94	2	0.5623	2	0.5623	2	2	0
5 PM:	94	2	0.5623	2	0.5623	0	2	0
Total		23	6.3966	23	6.3966	21	23	19

Notes - No. 165 appeared to be in good condition at 1 P. M., July 10 but was found dead at 5 P. M. Nos. 163 and 166 left the nest at that time, and No. 164 the next morning.

The experiment was discontinued, leaving No. 167 in the nest.

TABLE LII

DATA ON FEEDING GRASSHOPPERS TO ENGLISH SPARROW NESTLINGS

Date	% Poisoned	Poisoned grasshoppers No. 168 Wt. 20 gms. No. eaten	Amount arsenic in mgs.	Poisoned grasshoppers No. 169 Wt. 21 gms. No. eaten	Amount arsenic in mgs.	Unpoisoned grasshoppers No.170 Wt. 20 gms. No. eaten	Unpoisoned grasshoppers No.171 Wt. 19 gms. No. eaten	Unpoisoned grasshoppers No.172 Wt. 15 gms. No. eaten
7-7								
12 AM:	92	3	0.8255:	3	0.8255:	3	3	3
1 PM:	92	2	0.5503:	2	0.5503:	2	2	2
5 PM:	92	2	0.5503:	2	0.5503:	2	2	2
7-8								
8 AM:	92	3	0.8255:	3	0.8255:	3	3	3
1 PM:	92	3	0.8255:	3	0.8255:	3	3	3
5 PM:	92	2	0.5503:	2	0.5503:	3	2	2
7-9								
8 AM:	92	3	0.8255:	3	0.8255:	3	3	3
1 PM:	94	2	0.5623:	2	0.5623:	2	2	2
3 PM:	94	2	0.5623:	2	0.5623:	2	2	2
7-10								
8 AM:	94	2	0.5623:	2	0.5623:	2	2	2
1 PM:	94	2	0.5623:	2	0.5623:	2	2	2
5 PM:	94	2	0.5623:	2	0.5623:	2	2	2
7-11								
8 AM:	94	2	0.5623:	2	0.5623:	2	2	2
11 AM:	94	2	0.5623:	2	0.5623:	2	2	2
5 PM:	94	2	0.5623:	2	0.5623:	2	2	2
7-12								
8 AM:	94	2	0.5623:	2	0.5623:	2	2	2
Total:		36	10.0136:	36	10.0136:	36	36	36

Notes - The birds appeared normal at all times and all left the nest normally except No. 172, which was still in the nest when the experiment was discontinued.

The indications here were that poisoned grasshoppers had no effect on English sparrow nestlings.

Table LIII summarizes the results of Tables XXVII to LII, inclusive. In formulating this table, it was assumed that the birds found dead in the nest were killed by the grasshoppers fed, regardless of whether the grasshoppers were poisoned or unpoisoned. It is realized that other factors, especially handling, were at least partially responsible for their death, but since there was no method of measuring the effect of the other factors, it was decided to work under the assumption above mentioned.

TABLE LIII

SUMMARY OF EXPERIMENTS IN FEEDING NESTLING BIRDS

Species	No. matured		No. apparently killed from eating grasshoppers		No. disappeared, or died from other causes	
	Birds fed poisoned hoppers	Birds fed unpoisoned hoppers	Birds fed poisoned hoppers	Birds fed unpoisoned hoppers	Birds fed poisoned hoppers	Birds fed unpoisoned hoppers
Mocking birds	5	6	3	1	5	4
Robins	2	1	0	0	0	1
Meadow larks	2	3	3	1	0	0
Black birds	3	2	2	0	1	2
Brown thrasher	0	2	3	2	6	2
Dickcisel	3	3	0	0	2	1
Orchard orioles	1	1	0	0	0	0
Lark sparrows	0	0	0	0	2	2
Scissor-tails	2	3	0	0	0	0
English sparrows	4	5	0	1	0	0
Total	22	26	11	5	16	12

Referring to Table LIII, it will be seen that 49 birds were fed poisoned grasshoppers and 43 birds were fed unpoisoned grasshoppers.

(3) Discussion. In attempting to analyze the results of these experiments, the following questions arise: (1) How many grasshoppers will birds eat at any one time or during one day? (2) Will birds pick up large numbers of dead grasshoppers from the ground for their food or do they prefer to catch living grasshoppers? (3) How much will the answers to the first two questions be affected by the presence of a heavy grasshopper infestation and successful poisoning operations?

It is the writer's opinion that the answer to these questions would show that at least the great majority of birds would not pick up and eat or feed on as many poisoned grasshoppers as were fed in several of these experiments when the birds matured normally. If this were the case, these experiments would indicate quite definitely that in most cases no injury would result from the eating of poisoned grasshoppers.

However, a search of the literature shows that the questions have not been answered. A very large number of stomach analyses of nestling birds have been made and many observations have been made as to the food the parent birds carry to their young, but the writer was able to find only a

small amount of data as to the number of grasshoppers fed in any given period under either normal or heavy infestations of grasshoppers, and no data at all as to the habits of the birds in picking up and eating or feeding on dead grasshoppers, poisoned or unpoisoned.

The experiments with the domestic birds and quail would indicate that even though wild birds are known to pick up and eat or feed to nestlings a sufficient number of dead grasshoppers to kill them in case they were poisoned, it seems probable that they might reduce the number eaten after eating a few of the poisoned grasshoppers.

In the absence of this information, it seems that any conclusions will have to be derived from the information contained in these experiments. It may be seen that this probably is too varied to permit the drawing of definite conclusions, for arguments on both sides of the question are present. Those indicating that poisoned grasshoppers are injurious will be discussed first. They are as follows:

(1) Table LIII shows that, of the 49 birds that were fed poisoned grasshoppers, only 22 or 44.89 per cent matured normally; while of the 43 fed unpoisoned grasshoppers, 26 or 60.46 per cent matured normally. This seems to indicate quite directly that the poisoned grasshoppers were more injurious than those that were unpoisoned.

(2) Table LIII also shows that of the 49 birds that were fed poisoned grasshoppers, 11, or 22.45 per cent, died apparently from the effect of the grasshoppers, while of the 43 fed unpoisoned grasshoppers, only 5, or 11.63 per cent, appeared to be killed from the effect of the grasshoppers. In this case, approximately double the percentage were killed by poisoned grasshoppers of those killed by unpoisoned grasshoppers, which also indicates rather definitely that the poisoned grasshoppers were more injurious.

(3) As pointed out on page 172, several of these birds consumed a greater amount of arsenic in proportion to their weight than was received by Chicken No. 3 (see page 52). This chicken before death exhibited symptoms of arsenical poisoning and the autopsy indicated that the arsenic was responsible for its death. Therefore, it seems probable that the birds eating a greater proportionate amount of arsenic would be injured.

(4) In none of these experiments was it possible to get any of the birds to eat as many grasshoppers as the literature on the subject indicates they are capable of eating. For instance, Judd (30) states that Aughey observed wrens to carry as many as 30 Rocky Mountain locusts to their nests in the course of an hour. It was not stated how many young were in the nest nor how large the grasshoppers were, but if

this number per hour were carried for very many hours during the day, the numbers would soon be much greater than any fed during these experiments. McAtee, in the same paper, also mentions a young robin that consumed 60 earthworms daily for a few days. Again no mention is made as to the size of the earthworms, but unless they were quite small it would seem that an equivalent amount of grasshoppers would constitute an amount greater than any of the experimental birds could be gotten to eat.

However, in spite of the comparatively small numbers eaten, the death rate was higher and the percentage maturing was lower in those birds receiving poisoned grasshoppers than in those receiving unpoisoned grasshoppers. Any or all of the above points indicate greater injury from poisoned grasshoppers than from unpoisoned, which in turn indicates that the arsenic contained in their bodies was injurious to the birds eating them.

As before stated, the data from these experiments, also indicate that the poisoned grasshoppers or the arsenic contained in their bodies is not injurious, or at least, not lethal to birds. This side of the discussion follows:

(1) A number of the birds that matured normally (Nos. 79, 80, 102 and 103) ate more grasshoppers and consequently more arsenic than any of those that apparently were killed by the poisoned grasshoppers. This would indicate that the death

of those that died may have been due to some other cause.

(2) In none of the cases where the birds appeared to have been killed by the poisoned grasshoppers was the evidence conclusive. Mocking birds Nos. 82 and 83 (see table XXIX) appeared to have been killed by the poisoned grasshoppers, and yet when another bird from the same nest (No. 84) was placed on a poisoned grasshopper diet, it consumed several times the number of grasshoppers eaten by either No. 82 or 83 and matured normally. This might be taken to mean that younger birds are more easily affected, since No. 84 was 1½ days older when placed on the poisoned grasshopper diet. However, Table XXI shows that smaller and presumably younger birds (Nos. 86 and 87) fed for three days on poisoned grasshoppers with no signs of injury; while Nos. 82 and 83 died at the end of 1½ days. Thus, Nos. 86 and 87 refute the argument that the age was responsible, and numerous others indicate that the numbers of grasshoppers or amount of arsenic was not responsible.

Tables XXXV and XXXVI indicate that meadow larks Nos. 106, 107 and 109 were killed by poisoned grasshoppers. It is also seen, however, that No. 110, which was the same weight as the smallest one that died, consumed a greater amount of arsenic than any of the three that died and yet matured normally. This makes it appear that in this case also, the

arsenic may not have been responsible for the deaths.

Tables XXXVIII to XL show that black birds Nos. 123 and 126 appeared to have been killed by poisoned grasshoppers, but of the four that were uninjured three had consumed more arsenic than either of the two that died. In the case of blackbirds, however, No. 126 was the smallest one fed; therefore in this case no check was available to check the effect of the arsenic on smaller birds.

Tables XLIV and XLV indicate that brown thrashers Nos. 139, 140 and 142 were killed from eating poisoned grasshoppers. In this case, the effect the poisoned grasshoppers may have had is not clear or definite due to the fact that of the 6 check birds only one was known to have reached maturity and 2 appeared to be killed by eating unpoisoned grasshoppers. In view of the fact that nearly as many checks died as experimental birds and that such a small per cent of the check birds matured even though they received no poisoned grasshoppers, it appears that in this case some other factor than the arsenic was responsible for the majority of the deaths occuring in these birds.

This completes the list of those that apparently were killed by eating poisoned grasshoppers and it is seen that in each case the evidence is far from complete.

(3) In the marking of the birds for identification,

weighing and feeding of the birds, they were necessarily handled a great deal and this, it seems probable, was at least partially responsible for the death of some of the birds.

(4) Considering each nest as a separate experiment, 12 indicate that poisoned grasshoppers do not kill birds and only 4 indicate that they do. In the other experiments, no definite indications are seen either way. Thus, there is three times as much evidence that they are not injurious as that they are.

(5) From the writer's observation of the habits of wild birds in general, as well as the slight amount found in literature on this topic, it seems probable that a large portion of the grasshoppers eaten by birds are captured alive, rather than picked up from the ground after death. In this case, it is probable that a comparatively small per cent of those eaten would contain arsenic, for the larger per cent of the living grasshoppers have not eaten of the poison bait.

(6) In view of the fact that domestic birds recognize the injurious nature of poisoned grasshoppers and reduce the number eaten when they contain arsenic, it seems reasonable to believe that wild birds would do the same. Also since parent birds, while feeding the young, eat a portion of the food, they probably would stop feeding poisoned grasshoppers

to their young, after they themselves had eaten a few. Still another possibility is that the young birds also recognize any injurious nature poisoned grasshoppers may have and refuse to eat more.

(7) According to Judd (30), nestling birds in a large percentage of the cases, consume a great deal greater proportion of animal food (largely insects) than do adult birds. Also, young animals are considered to be more susceptible to arsenical poisoning than are adults. These statements, together with the fact that so many of the nestling birds matured even though they ate large numbers of poisoned grasshoppers, seem to indicate that the danger of adult birds being poisoned from this source is very small. In this connection, it is interesting to note that in many cases, the breeding season of song birds is nearly over at the time poisoning operations are conducted, and in these cases there would be no danger to nestlings and only very slight danger, if any, to adult birds.

(3) Conclusions. The evidence presented above indicates to the writer that

1. Nestling robins can consume as many as 134 poisoned grasshoppers, containing 39.9860 mgs. of As_2O_3 and still mature normally.

2. Poisoned grasshoppers, in the numbers fed in

these experiments are somewhat injurious to nestlings.

3. Most of the deaths occurring in these experiments were due to a combination of the arsenic contained in the poisoned grasshoppers, unnatural feeding conditions and excessive handling, rather than to arsenic alone.

4. The danger, if any, to adult birds is very slight.

D. Possibility of Poisoning Humans Through the Eating of Chickens that had Fed upon Poisoned Grasshoppers.

This possibility at first glance appears so remote that it scarcely seems worthy of investigation. However, in a few cases rumors to the effect that people were thus poisoned have been circulated to such an extent that grasshopper poisoning campaigns have been seriously hampered.

During the summer of 1924, there was a serious outbreak of grasshoppers in the western and southwestern parts of Oklahoma and in some communities such reports were very common. Prof. E. E. Scholl, who was Extension Entomologist of Oklahoma at that time, in conversation with the writer, told of the following incidents: In Logan County, a women's club had served boned chicken at one of their meetings. Soon after, a number of the women became ill. Since grasshopper

poisoning was being conducted there at that time, it was assumed by a number of the people of the community that this illness was due to the arsenic in the bodies of the chickens obtained through feeding on poisoned grasshoppers. The feeling ran so high that petitions were circulated with the intention of sending them to the Governor in an attempt to put a stop to the spreading of poison.

This same year similar reports were circulated in Comanche, Jefferson, and Stevens Counties and resulted in destroying local markets for chickens. Persons ordering chicken in some of the restaurants were told that it was not considered safe to serve chickens at that time, and as a result the restaurants did not carry a supply of chickens.

Barber (1) tells of similar reports being circulated in the vicinity of Oakley, Idaho, and Prof. R. B. Thompson of the Poultry Department of Oklahoma A. and M. College, told the writer that a few years ago, while working in New Mexico, he heard similar reports in the communities of Alamagorda and Portales.

In this connection it is interesting to recall that only a few years ago we practically refused to consider the possibility of persons being poisoned through eating fruit that had been properly sprayed. However, the officials of various governments, including our own, have considered this

possibility of sufficient importance to pass strict rulings requiring the arsenical residue on fruit to be drastically reduced from the amount commonly found on fruit. In view of these facts, it was felt the possibility of human poisoning from this source should be investigated.

According to Holland (26), 2 grains of arsenic is the smallest fatal dose of arsenic to humans known. This is equal to 129.6 mgs.

1. Presentation of data.

The following figures were taken from the previous tables in this paper.

The greatest amount of arsenic eaten in any one day by chickens was 37.7250 mgs. (No. 41 on Aug. 4) Wt. 1 lb. 7 oz.; by turkeys was 28.0622 mgs. (No. 55 on July 30) Wt. 1 lb. 13 oz.; by ducks was 101.9373 mgs. (No. 57 on Aug. 27) Wt. 4 lb. 12 oz.

Since 129.6 mgs. is the minimum lethal dose of As_2O_3 129.6 ÷ 37.7250 = 3.44. It can be seen that it would require almost 3½ chickens weighing 1 lb. 7 oz. eating the maximum amount of arsenic to eat 129.6 mgs. of arsenic. In other words, a person would have to eat almost 3½ chickens, in their entirety, including the contents of their digestive tracts, to receive a lethal dose. Furthermore, it seems probable that

a part of this arsenic would be eliminated by the chickens before the final portion of it was consumed, in which case the amount required to be eaten would be increased in proportion to the amount eliminated.

By this same method of reasoning, it will be seen that it would require 4.62 turkeys weighing 1 lb. 13 oz. or 1.27 ducks weighing 4 lb. 12 oz.

Since it is not even in the range of possibility that any one would consume, in their entirety, the above number of birds the only other chance of receiving a toxic or lethal dose from chickens would be for the chickens to store up the arsenic in the edible portions of the body.

In order to test this possibility, portions of a number of these experimental birds were analyzed for their arsenical content. The samples were made up as shown in Table LIV..

TABLE LIV

MAKE-UP OF SAMPLES ANALYZED FOR ARSENICAL CONTENT

Sample No.	Portion of chicken	Chicken No.	Type of hoppers fed
1	Liver	29,30,33,34	Poisoned
2	Gizzard	29, 30, 33, 34, 37	Poisoned
3	Heart	29, 30, 33, 34, 41, 3, 4	Poisoned
4	Kidney	29, 30, 33, 34, 37, 41, 3,4	Poisoned
5	Flesh	29, 30, 33, 34, 37, 41	Poisoned
6	Intestines	29, 30, 33, 34	Poisoned
7	Liver	31, 35, 40	Unpoisoned
8	Gizzard	31, 35, 38, 40	Unpoisoned
9	Heart	31, 35, 38, 42	Unpoisoned
10	Kidney	31, 35, 38, 42	Unpoisoned
11	Flesh	31, 35, 42	Unpoisoned
12	Intestines	31	Unpoisoned
13	Liver	38, 42	Unpoisoned
14	Liver	37, 39, 41	Poisoned
15	Liver	3, 4	Poisoned
16	Gizzard	3, 4	Poisoned
17	Flesh	3, 4	Poisoned

Table LV gives the results of these analyses.

TABLE LV

ARSENICAL CONTENT IN SAMPLES OF PORTIONS OF CHICKENS FED VARYING AMOUNTS OF ARSENIC

Sample No.	Portion of chicken	Total arsenic in sample, as As_2O_3	Arsenic as As_2O_3 parts per million
1	Liver	0.03 mg.	0.5
2	Gizzard	2.80	63.4
3	Heart	0.44	1.8
4	Kidney	0.16	0.7
5	Flesh	0.24	1.5
6	Intestines	0.009	1.1
7	Liver	0.002	0.5
8	Gizzard	0.013	0.3
9	Heart	0.008	0.7
10	Kidney	0.014	1.0
11	Flesh	0.008	0.6
12	Intestines	0.009	3.4
13	Liver	0.016	0.5
14	Liver	0.038	1.4
15	Liver	0.280	9.9
16	Gizzard	0.250	7.9
17	Flesh	0.056	4.2

2. Discussion.

This table shows that sample No. 2 has an exceedingly heavy arsenical content, as compared to the other portions of the chickens. These gizzards were not opened and cleaned as in preparing for the table, and, since this sample varies so widely from all others, it seems probable that a small amount of arsenic must have been lodged in the folds of the lining of the gizzard rather than in the tissue proper. For our purpose, however, it may be assumed that the arsenic was

incorporated in the tissue of the gizzard and would be eaten if the gizzard were eaten.

Since this tissue contains 63.4 parts per million, 1 million mgs. of gizzard would contain 63.4 mgs. of arsenic. Since 139.6 mgs. is a lethal amount and 63.4 mgs. is 48.92 per cent of it, 1,000,000 mgs. contains 48.92 per cent of a lethal amount. Therefore, 2,040,000 mgs. of gizzard would be required to contain this lethal amount. This is 2,040 gms. or 4.49 pounds. This would indicate that a person in order to receive the minimum lethal amount of arsenic through chicken gizzards would first have to obtain gizzards each one of which contained an exceptionally high arsenical content, and then consume 4.49 pounds of them.

The next highest arsenical content was in sample No. 15, which was chicken livers. By the same method of figuring as used before, it is found that in order to obtain a lethal amount of arsenic from chicken livers 28.86 pounds of them would have to be eaten.

These figures also show that 68.03 pounds of flesh would have to be eaten to obtain the minimum lethal dose.

3. Conclusions.

From the above data, it is concluded that (1) There

is no danger at all of receiving a lethal amount of arsenic from eating chickens that have fed on poisoned grasshoppers. (2) The margin of safety is so great that the possibility of receiving a slightly toxic dose is so extremely remote as to be of no consideration.

IV. SUMMARY

A review of the literature shows that ever since poison bran mash has been used for the control of grasshoppers, it has been thought by some that its use endangered domestic fowls and wild birds. It also shows that although the question has been argued for years, an extremely small amount of experimental work has been carried on to determine the truth of such statements.

This paper is the report of experiments carried out in an attempt to answer the following questions:

Will birds be injured from picking up the poisoned bran? Will they be injured from eating the poisoned grasshoppers? Is there any danger to humans or other animals from eating chickens that have fed on poisoned grasshoppers?

Domestic fowls and quail were confined in pens and left without food for 24 hours. Poisoned bran was then scattered in the pens at the rate of 100 pounds per acre and the fowls were left another 24 hours without other food. No indications of poisoning appeared. From this it was concluded that birds will not be injured through picking up well scattered poisoned bran.

Feeding experiments in which poisoned bran was force fed to chickens indicated that 74 mgs. of white arsenic (As_2O_3) constituted a slightly toxic dose for a 22 ounce chicken. From this it was assumed that 3.363 mgs. per ounce of bird weight constituted a slightly toxic dose.

Other experiments and chemical analyses were conducted to determine the amount of arsenic contained in poisoned grasshoppers.

A series of experiments was then conducted in which 144 birds, including chickens, turkeys, ducks, quail, and the nestlings of various species of song birds, were fed 17,377 poisoned and unpoisoned grasshoppers. These experiments were continued from 10 to 66 days.

From the experiments, the following conclusions were drawn concerning domestic fowls:

1. They readily recognize the fact that poisoned grasshoppers are not as desirable a food as unpoisoned grasshoppers. As a result of this,

2. They will eat less than half the number of poisoned grasshoppers that they will of unpoisoned grasshoppers.

3. The amount of arsenic consumed through feeding on poisoned grasshoppers averages much less than one-half of a toxic dose.

4. Even though no other food is available for a

period of ten days, they will not eat a sufficient number of grasshoppers to obtain a toxic dose.

5. The arsenic obtained through eating the poisoned grasshoppers does not have a cumulative effect even though the fowls were fed for a period of 66 days.

Concerning quail, the following conclusions were drawn:

1. Even though quail eat the maximum number of grasshoppers they have ever been recorded as having eaten, they will not be noticeably injured though each of the grasshoppers was killed by feeding on poisoned bran.

2. Quail eating the number of grasshoppers normally eaten probably receive only from 1 to 7 per cent of a toxic dose.

Concerning wild birds, it was concluded:

1. Nestling robins and presumably other species of a similar size, can consume as many as 134 poisoned grasshoppers containing 39.986 mgs. of As_2O_3 and still mature normally.

2. Poisoned grasshoppers may be somewhat injurious to nestling birds, although the evidence is incomplete.

3. There is very little danger, if any, to adult wild birds.

Figures taken from the above work showed that chickens never consumed a sufficient amount of arsenic at any one time to constitute a dangerous dose for humans, and therefore the only possibility of humans receiving such an amount from eating chickens was for the arsenic to be stored in the edible portions of the body.

Chemical analyses of the bodies of a number of chickens that had eaten large numbers of poisoned grasshoppers were made. These analyses showed definitely that there is no danger of humans being poisoned from eating chickens that have eaten poisoned grasshoppers.

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